Hospital treated deliberate self-harm: mortality risk and area level associations – a national registry cohort study

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List of Abbreviations

AIRO	All-Island Research Observatory
CDC	Centre for Disease Control
CI	Confidence Interval
CREC	Clinical Research Ethics Committee of the Cork Teaching Hospitals
CSO	Central Statistics Office
DED	District Electoral Division
DROs	Data Registration Officers
DSM	Statistical and Diagnostic Manual of Mental Disorders
ED	Emergency Department
GP	General Practitioner
GRO	General Register Office
HR	Hazard Ratio
HRB	Health Research Board
HSE	Health Service Executive
ICD	International Classification of Diseases
IMD	Index of Multiple Deprivation
IRR	Incidence Rate Ratio
NICE	National Institute for Health and Care Excellence Clinical Excellence
NOSP	National Office for Suicide Prevention
NCP	National Clinical Programme
NRDSH	National Registry of Deliberate Self Harm Ireland
NSRF	National Suicide Research Foundation
NSSI	Non-Suicidal Self-Injury
NSSS	National Suicide Surveillance System
OCDS	Operational Criteria for the Determination of Suicide
ORLS	Oxford Record Linkage Study
PPV	Positive Predictive Value
RCTs	Randomised Controlled Trials
ROI	Republic of Ireland
RR	Relative Risk
SIR	Standardised Incidence Ratio
UCC	University College Cork
UHI	Unique Health Identifier
UK	United Kingdom
WADLS	Western Australia Data Linkage System
WHO	World Health Organisation

Declaration

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism.

Signed:

Date:

Dedication

I would like to dedicate this thesis to my late aunt Clare Langford

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Thesis Abstract

Introduction

Suicide is a major public health problem. Suicide is hard to predict, however research has identified that deliberate self-harm is the strongest predictor for future suicide. The magnitude of the risk of suicide and non-suicide external causes of death (mainly poisonings, falls and road traffic accidents) in the period following a hospital presentation with self-harm, has not been well estimated in representative samples of well-defined patients. Furthermore, to better understand the causes of suicidal behaviour the characteristics of the areas in which people reside need to be examined also. An ecological perspective on suicidal behaviours examines how area level characteristics such as socioeconomic deprivation and social fragmentation influence small area rates of deliberate self-harm and suicide. The main aims of this thesis are to examine the risk of suicide and non-suicide external cause mortality in a cohort of individuals who have presented to hospital due to self-harm in the Republic of Ireland. Additionally, the ecological relationship between suicidal behaviour (both self-harm and suicide) and area level determinants in the Republic of Ireland will be examined.

Methods

To identify mortality due to external causes among the self-harm patient cohort, the National Registry of Deliberate Self Harm Ireland data (for the years 2009-2011) was linked using probabilistic data linkage techniques to official external cause mortality data (for the years 2009-2011). Separate negative binomial regression models were used to examine the relationship

between deliberate self-harm and area level determinants and suicide and area level determinants.

Results

Findings from the linkage study showed that 437 of 26,168 self-harm patients died from external causes during the study follow-up. The 1-year cumulative incidence for suicide, non-suicide external cause mortality and all external causes combined were 0.8% (95%CI 0.7-0.1), 0.5% (95%CI 0.4-0.6) and 1.3% (95%CI 1.2-1.5), respectively. The risk of suicide was 46 times (95% CI 39-54) greater in self-harm population compared to the general population. The risk of non-suicide external cause mortality was 22 times greater (95% CI 18-27) in the self-harm population compared to the general population. Findings from the self-harm area-level study showed that socioeconomic deprivation, social fragmentation and population density had a positive linear association with self-harm, with socioeconomic deprivation having the strongest independent effect. Findings from the suicide area-level study showed that socioeconomic deprivation had the strongest independent effect on small-area rates of suicide.

Discussion

The findings of this thesis show the extremely high risk of death from suicide and non-suicide external causes following hospital presentation with self-harm. Furthermore, this thesis demonstrates the marked geographical inequalities in the distribution of both suicide and self-harm in Ireland and highlights the importance of targeting suicide prevention resources in the most deprived areas.

Chapter 1

Introduction

Introduction

This chapter provides an overview of the entire thesis. Firstly, the definitions of fatal suicidal behaviour (completed suicide) and non-fatal suicidal behaviour (deliberate self-harm) will be discussed. The incidence of fatal and non-fatal suicidal behaviour both internationally and in the Republic of Ireland will also be described. Then the general aims and specific research questions will be outlined. A breakdown of the thesis chapters is also provided. The relevant literature will be discussed in Chapter 2. Chapter 2 places the thesis in the context of the relevant studies that have examined the risk of suicide in the deliberate self-harm population. Therefore, Chapter 2 will focuses on the relevant literature that has examined the risk of subsequent suicide in populations presenting to a hospital setting due to deliberate self-harm.

Fatal suicidal behaviour - Completed suicide - Definitions and Terminology

Suicide is the standard terminology that is used worldwide to describe an act of fatal suicidal behaviour. There are many definitions of suicide. The Centre for Disease Control (CDC) define suicide as '*Death caused by self-directed injurious behaviour with an intent to die as a result of the behaviour'*. The World Health Organisation (WHO) defines suicide as an act of deliberately killing oneself. Determining if a death was due to suicide is not a straightforward task for coroners and medical examiners. The CDC developed an Operational Criteria for the Determination of Suicide (OCDS) to guide coroners and medical examiners in classifying the cause of death as a suicide.[1] The OCDS defined suicide in accordance with three evidential

component elements (1) the death must be as the result of injury of some sort rather than from illness or disease, (2) the death must be self-inflicted and (3) the death must be intentionally inflicted. However, there is no international standardised system for determining suicide as the cause of death.

Accurate and reliable suicide statistics are essential for monitoring trends in suicide, understanding its causes and for planning and assessing the effectiveness of suicide prevention strategies. However, suicide registration is a complex, multilevel procedure that involves medical and legal authorities and can vary from country to country.[2] In countries such as the United Kingdom and Australia the certification of an unexpected death is done by coroners, in America it is done by coroners and medical examiners, in Finland it is done by the police and in China it is done by physicians.[3] In Ireland the system for certifying a suicide death involves a number of professionals such as coroners, medical practitioners, police, pathologists, registrars, and vital statistics officers. Ireland operates a coronial system but the opinion of the police (An Garda Siochana) is also involved. The vital statistics officer in the Central Statistics Office (CSO) - the official body that records and codes mortality data in Ireland, uses the opinion of the police when coding the cause of death. Coroners in Ireland operate under the legal criteria of 'beyond reasonable doubt' for determining a suicide verdict while the other professionals involved such as the police and the vital statistics officer operate under the 'balance of probabilities approach'.[4]

Misclassification of suicides can lead to inaccuracies in official suicide statistics data. Suicide deaths are most commonly found misclassified

according to the codes of the 10th edition of the International Classification of Diseases and Related Health Conditions (ICD-10) as “deaths of undetermined intent” (ICD-10 codes Y10-Y34), and also as “accidents” (codes V01-X59), “homicides” (codes X85-Y09) and “unknown cause” (codes R95-R99). Research in England has demonstrated that the majority of deaths given an open verdict by a coroner are suicides.[5] Therefore, it is common practice in suicide research in the United Kingdom to combine deaths with an open verdict with suicide deaths. Recent research in England suggests that consideration should be given to the inclusion of ‘accidental’ deaths by poisoning with medicines with suicide mortality data to enable more accurate monitoring of suicide trends.[6]

Even though there are issues with under reporting, misclassification and differences in suicide recording practices between countries studies have shown that suicide trends over time[7] and comparisons of suicides rates between countries are still valid.[8]

The Incidence of Suicide Internationally

In 2012, the WHO estimated that 800,000 people died by suicide, this represents an annual global age-standardized rate of about 11.4 suicide deaths per 100,000 persons (15.0 for males and 8.0 for females).[2] This is likely to be an inaccurate estimate as not all WHO member states have comprehensive and good quality vital registration mortality data. The incidence of suicides varies greatly between countries and within countries.[3] The WHO reported that in 2012 the worldwide age-standardized suicide rates ranged from 0.4 to 44.2 per 100,000 – representing a 110-fold range. However, caution should be applied when interpreting this finding as only 60

of the 172 member countries on which the estimates are based have good quality suicide data, for the remaining 112 countries the estimates are derived from modelling methods. Of the 60 countries with good quality suicide mortality data, there is a 32-fold range in national age-adjusted suicide rates (from 0.89 to 28.85 per 100,000). This would suggest that the geographic variation in suicide rates is real and not an artefact, reflecting the differing reporting and recording procedures across countries. More than three quarters of the suicides worldwide occur in low- and middle-income countries. Within Europe, rates are generally higher in northern countries than in southern countries. For example, the WHO reported that in 2012 the age-standardized suicide rate in Finland (which has the highest suicide rates among the Nordic countries) was 14.8 per 100,000 and in Italy and Spain rates were are as low as 4.7 and 5.1 per 100,000 respectively. However, some of the highest rates are found in the Eastern European countries, for example age-standardized suicide rates were as high as 28.2 per 100,000 in Lithuania and 20.1 per 100,000 in Ukraine. Elsewhere age-standardized suicide rates were 12.1 per 100,000 in United States, 9.8 per 100,000 in Canada, 10.6 per 100,000 in Australia and 9.6 per 100,000 in New Zealand. In Asia high rates were found in Japan and the Democratic Republic of Korea, 18.5 and 28.9 per 100,000 respectively.

The Incidence of Suicide in the Republic of Ireland

In 2012 the WHO reported that the age-standardized suicide rate per 100,000 in the Republic of Ireland for all persons, males and females was 11.0, 16.9 and 5.2 respectively.[2] Although Ireland does not have the highest overall rates of suicide in Europe when all ages and both genders are

combined, it was found to have the highest rates of suicides in young females and the second highest rates in young males in Europe.

Accuracy of suicide statistics in Ireland

In Ireland there has been concern over the accuracy of suicide statistics. Cultural and legal issues have contributed to the underreporting of suicide deaths in official mortality data. Suicide in Irish society has historically been associated with stigma, guilt and shame.[4] As a consequence, there can be concealment of the nature of death either by the deceased themselves or the bereaved family members. The stringent legal 'criteria of beyond a reasonable doubt' that coroners in Ireland operate under requires that it must be evident that the death was due to unnatural causes and the death was self-inflicted, which in many cases is often hard to establish. Furthermore, some coroners may give open or accidental verdicts to avoid adding to the bereaved family's distress.

McCarthy and Walsh were the first to investigate the underreporting of suicide in Dublin during the 1950's and 1960s.[9] They found that underreporting was considerable, and that a large number of suicide deaths were misclassified as accidental deaths. A further study by the authors concluded that official suicide statistics should be multiplied by a factor of three to reflect the true rate of suicide.[10] In 1968, the cause of death category 'deaths of undetermined intent' was introduced by the Central Statistics Office. This led to an increased number of suicides death being classified as undetermined deaths during this period. Walsh reports that in 1968 the number of officially recorded suicidal deaths was 71 and those returned as

undetermined was 87, in 2003 the respective figures were 497 and 87, implying that the number of undetermined deaths relative to the number of suicide deaths has decreased in recent decades.[11]

Non-fatal suicidal behaviour - Definitions and Terminology

Historically, suicide acts that did not result in death were termed ‘attempted suicides’ or ‘suicide attempts’. In recent times, the term deliberate self-harm has become the umbrella term for non-fatal suicide attempts that encompass self-inflicted injuries and sell-inflicted poisonings. There is no consistent and universal term for non-fatal suicidal behaviours; therefore many different terms with varying meanings have been used in suicide research. A review by Skegg [12] identified the following terminologies in literature: deliberate self-harm, parasuicide, self-injury, self-mutilation and attempted suicide. Much of the debate over the terminology and definition of non-fatal suicide centres around the issue of suicidal intent and motivation. Some experts and researchers believe that there should be a distinction between acts where there is an intention die (suicide attempts) and acts where there is no supposed intention to die, non-suicidal self-injury (NSSI). In the Unites States, prominent definitions of deliberate self-harm excludes suicidal ideation injuries.[13, 14] Whereas, in the United Kingdom, the term deliberate self-harm encompasses behaviours irrespective of suicidal intent or motivation.[15]

The incidence of non-fatal suicide internationally

Non-fatal suicidal behaviours are more common than suicides[16, 17] but there is conflicting information about the incidence of non-fatal suicidal behaviours worldwide. Differences in estimates arise from different study methodologies,

to whether the definition encompasses suicidal intent, and the different populations from which the rate estimates are based (e.g. hospital populations versus community populations.[18] There are indications that for each adult who died of suicide there may have been more than 20 others attempting suicide.[2] Obtaining precise and accurate estimates of non-fatal suicidal behaviour is difficult because continuous, population based monitoring of suicidal behaviours is rare.[19] There are two main methods for obtaining data on suicide attempts: from surveys of self-reported suicidal behaviour carried out on representative samples, and from medical records (primarily hospital records) about treatment for deliberate self-harm.[2] Hospital record data has typically been used to estimate the incidence of non-fatal suicidal behaviour, as this data is collected systematically by many countries and contains information about whether an injury is self-inflicted, the characteristics of the method, and whether the person died during the hospital stay.[20] Hospital data has been used by many countries to carry out studies investigating the epidemiology of non-fatal suicidal behaviour, these countries include: United Kingdom, the Nordic Countries, Ireland, United States, Canada, New Zealand and Australia, and in more recent years countries in the Far East. Hospital data comprises of emergency department presentation data and hospital admissions data. Emergency department (ED) data has been argued as providing more representative deliberate self-harm information than inpatient admission data because usually only more medically serious individuals are admitted to hospital.[20] In the literature to date, both ED presentation data and in-patient admissions data have been used to provide estimates of non-fatal suicidal behaviours. The WHO/Euro

Multicentre study on Suicidal Behaviour provides the most comprehensive figures on the incidence of medically treated non-fatal suicidal behaviour to date.[21] The WHO/Euro Multicentre study has complied data from 25 centres in 19 different countries, and its use of standardised methodology has allowed for international comparisons to be made. Findings from the WHO//Euro Multicentre study from the period 1995-1999, showed the average European rate for non-fatal suicidal behaviour was 170 per 100,000 for males and 209 per 100,000 for females. A huge variation in rates of non-fatal suicidal behaviour across Europe was demonstrated. For example, the highest rates of non-fatal suicidal behaviour were found among females in Rennes, France (500 per 100,000) and the lowest rates were found among males in Ankara, Turkey (36 per 100,000). Rennes (France), Oxford (England), and Pecs (Hungary), had the highest female rates and Oxford, Gent (Belgium), and Helsinki (Finland), had the highest male rates. Generally, rates of non-fatal suicidal behaviour were higher in females than males, with the exception of three centres, Helsinki, Tallin (Estonia), and Ljubljana (Slovenia) where the rates were found to be higher among males than females. Across Europe, rates of non-fatal suicidal behaviour varied by age, with the highest rates being found in adolescents and young adults and the lowest rates being found in the over 55 year age group.

The Incidence of Non-Fatal Suicide in the Republic of Ireland

The incidence of medically treated non-fatal suicide has been shown to be generally higher in the Republic of Ireland than in other European countries.[22] [21] In the Republic of Ireland, the National Registry of Deliberate Self-Harm (NRDSH) was established to determine and monitor the incidence

and repetition of deliberate self-harm to all hospital emergency departments across the Republic of Ireland. In 2012, Perry et al. published the first findings from the Registry on the incidence of hospital treated deliberate self-harm in at a national level in Ireland.[23] The findings of the study showed that average annual total, male and female rate of persons presenting to hospital with deliberate self-harm were 198 (95% CI: 196–200), 173 (95% CI: 171–175) and 224 (95% CI: 221–226) per 100,000, respectively. Higher rates of hospital treated self-harm were found among the young and young females in particular, with a clear peak in 15–19 year-old females (620 (95% CI: 605–636) per 100,000), which was almost twice the equivalent male rate (336 (95% CI: 325–347) per 100,000). In males, the highest rate was seen in the 20–24 year age group (427 (95% CI: 416–439) per 100,000).

Overall aims and objectives

The main aims of this thesis are:

(1) To carry out a national prospective registry cohort linkage study to calculate the risk of suicide and death from other external causes among self-harm patients presenting to hospital emergency departments across the Republic of Ireland from 2009 to 2011. The influence of potential risk factors such as age, gender, method of self-harm, self-harm repetition, involvement of alcohol and recommended next care will be examined.

(2a) To investigate the ecological relationship between self-harm incidence and the following area level constructs: socioeconomic deprivation, social fragmentation, population density, and travel time to the nearest hospital emergency department in the Republic of Ireland, from 2009 to 2011.

(2b) To visualise the spatial patterning of hospital treated deliberate self-harm in the Republic of Ireland from 2009 to 2013 through the use of geographical mapping techniques.

(3) To investigate the small area level association between suicide and the following three area level factors, socioeconomic deprivation, social fragmentation and population density, in the Republic of Ireland, from 2009 to 2011.

Thesis outline

Chapter 1: Introduction, aims and objectives.

Chapter 2: Review of the literature – risk of suicide after hospital treated deliberate-self harm

Chapter 3: Record linkage methodology

Chapter 4: Original research (Paper 1)- Hospital treated deliberate self-harm and risk of suicide and death from other external causes in the Republic of Ireland – a national registry cohort study

Chapter 5 Brief overview of the literature – The ecological association between deliberate self-harm and suicide area level factors

Chapter 6 (a): Original research - Characteristics of small areas with high rates of hospital-treated self-harm: Deprived, fragmented and urban or just close to hospital? A national registry study

Chapter 6 (b): Original research: A Short Report - Mapping the incidence hospital treated deliberate self-harm in the Republic of Ireland from 2009 to 2013

Chapter 7: Original research - The area level association between suicide, deprivation, social fragmentation and population density in the Republic of Ireland – a national study

Chapter 8: Discussion and overall conclusion.

Chapter 2

Review of the literature – Risk of suicide after hospital treated non-fatal self-harm

Review of the literature – Risk of suicide after hospital treated non-fatal self-harm

It is widely accepted that deliberate self-harm is one of the strongest risk factors for suicide. In this chapter existing literature that has examined subsequent suicide among the hospital treated deliberate self-harm population will be explored.

To date, two systematic reviews have been carried in this area. The first of these reviews, by Owens et al.[24] was published in 2002, and examined all relevant studies up until 2001. The second systematic review, by Carroll et al.[25] was published in 2014, and was in part, an update of the previous systematic review by Owens et al., and therefore included any relevant studies from the Owens et al. review and examined all relevant literature up until the end of 2012. My literature review will examine the key studies that have estimated the one year estimate of suicide among hospital treated self-harm patients identified in both of these reviews, in addition to any key studies that were published subsequent to the review by Carroll et al (i.e studies that were published between January 2013 and June 2016) will also be examined. As the study population in this thesis are hospital treated deliberate self-harm patients that were followed up prospectively, this literature review will focus on cohort studies that are based on hospital treated deliberate self-harm populations and have estimated the risk of suicide within one year after an episode of deliberate self-harm. Studies that focus solely on sub groups of the self-harm population such as patients with specific disorders such as schizophrenia are not included. Both the systematic reviews by Owens et al. and Carroll et al. included randomised

controlled trials (RCTs) and studies that were carried in other healthcare setting besides the hospital setting such as primary care, these studies are not examined in this literature review as the nature and design of these studies are not in keeping with the aims of this thesis.

Estimate of the 1-year risk of suicide after deliberate self-harm

Owens et al. found that the risk of suicide within the first year after an episode of deliberate self-harm lies somewhere between 0.5% and 2.0%. The systematic review by Carroll et al. showed that one year risk of suicide after deliberate self-harm was 1.6% (95% CI 1.2-2.4%). Carroll et al. identified 40 studies mortality follow up studies, of which 33 were cohort studies and seven were RCTs. Carroll found that whether the study was a RCT or cohort study had an impact on the estimates of the suicide risk. The one year risk of suicide was 1.0% (95%CI 0.5-2.0) for RCTs and 1.7% (95% CI 1.3-2.3) for cohort studies. Of the 33 cohort studies, the majority were from Nordic countries (n=17), seven were from the United Kingdom, three were from Australia and New Zealand, two were from Southern Europe and two were also from Asia. Carroll et al. showed that the rates of suicide after self-harm varied from country to country. The one year risk of suicide was 1.4% in New Zealand and Australia, 1.6% in Europe, 1.7% in Asia and 1.8% in Europe. Since the publication of the systematic review by Carroll et al. a number of follow up mortality studies among the hospital treated deliberate self-harm population have been carried out in Europe, North America, Australia and Asia.

The United Kingdom: 1-year risk of suicide after deliberate self-harm

The UK has a strong history of investigating the epidemiology and outcomes associated with hospital treated deliberate self-harm. This has in part been facilitated by the various monitoring systems that have been set up across centres in the UK to collect information on patients presenting to hospital due to self-harm. One of the longest running monitoring systems in the United Kingdom, the Oxford Monitoring System for Self-Harm was established in 1976 and collects information on individuals presenting to a general hospital in Oxford following self-harm. Subsequently, the Multicentre Study of Self-Harm in England was set up to provide representative and reliable data on the incidence of hospital treated self-harm, from five hospitals across three centres in England (one hospital in Oxford, three hospitals in Manchester and one hospital in Derby). In recent years, the Bristol Surveillance Register was established to collect data on individuals presenting to hospital due to self-harm in the Bristol area. The Bristol Self-Harm Surveillance Register started collecting data from one of the major hospitals in Bristol in 2010 and since 2013 it has expanded to include one other major hospital in Bristol.

The review by Carroll et al. identified seven mortality follow up studies carried out in United Kingdom that reported one year estimates of suicide risk after self-harm.[15, 26-31] Four of these studies were single centre follow-up studies conducted during the late 1960s and early 1970s and were based on relatively small sample sizes.[26, 28, 29, 31] All four of these studies found that the one year risk of suicide after self-harm was approximately 1%. The fifth study, published by Hawton et al. in 2003 was based on 11,583 patients who presented to hospital in Oxford from 1978-1997, this study found that the one

year risk of suicide was 0.7%.[15] The sixth study was a smaller single centre study carried out on 976 individuals who presented to hospital in Nottingham due to self-poisoning from 1985-1986 found that the one year risk of suicide was 0.5%.[30] The seventh study, which was the most recent UK study to be included in the systematic review, was based on findings from the Multicentre Study of Self-Harm in England, this cohort consisted of individuals who presented to hospital after self-harm from across three centres in Oxford, Manchester and Derby from 2000-2007 found that the one year risk of suicide was 0.7%.[27]

Since the publication of the review by Carroll et al., findings from a mortality follow up study based on a more recent cohort from the Multicentre Study of Self-Harm in England study have been published.[32] This study by Hawton et al. consisted of 40,000 self-harm patients who presented to hospital from 2000-2010 across the three centres in England and showed that that the one year risk of suicide after self-harm was 0.5%. This estimate is slightly lower than estimates from previous studies carried out in the UK. The authors of the study suggest that although the risk of suicide after self-harm is much greater among the self-harm population than the population in general, the lower rate may signify a reduction in the risk of suicide among the hospital treated self-harm population in recent years.

Two other single centre mortality follow up studies of hospital treated self-harm population have recently been published, one study was based on a cohort of self-harm patients that presented to a hospital in Leeds from 2000-2007,[33] and the other study was based on a cohort of self-cutting patients that presented to hospital in Bristol from 2010-2013,[34] however neither study

specifically reported the one year risk estimate for suicide after self-harm, hence comparisons of suicide risk estimates from these studies cannot be made.

Although no mortality follow up study of the hospital treated self-harm population has been carried at a national level in UK, the findings from the most recent cohort of the Multicentre Study of Self-Harm in England provides the most reliable and up to date estimate of the one year risk of suicide after self-harm in England.

The Nordic countries: 1-year risk of suicide after deliberate self-harm

The Nordic countries have shown some the highest risk of suicide after self-harm to date.

Denmark: 1-year risk of suicide after deliberate self-harm

In Denmark suicide research is strong; this is mainly due to the opportunities for linking complete nationwide registers of socio-demographic and health-related variables from the Danish Civil Register, National Registry of Patients, Psychiatric Central Registry, and Registry of Causes of Death. These registries provide detailed data and large sample sizes which are required for longitudinal studies on suicide and suicidal behaviour. This has facilitated a number of large and robust mortality follow up studies among individuals with self-harming behaviours to be carried out in recent years.[35] Three Danish cohort studies that estimated the risk of suicide within one year after a hospital treated suicide attempt were identified by Carroll et al. [36-38] These studies had small sample sizes and were restricted to a sub group of the self-harm population, individuals that were hospitalised due to a suicide

attempt. Two of these studies were based on cohorts from the late eighties and seventies and both reported that the one year risk of suicide after self-harm to be in excess of 2%.[36, 38] The third study was based on a more recent cohort from 2002 and reported a one year suicide risk of 1.7%.[37] Since the systematic review, the findings from two large national mortality follow up studies, by Erlangsen et al.[39] and Fedyszyn et al.[40] have been published. Erlangsen et al. examined individuals presenting to either a somatic or psychiatric hospital due to self-harm over a 19 year period from 1992 until 2010 (n=58,282) and found that the one year risk of suicide was 1.2%. Fedyszyn et al. examined individuals presenting to hospital due to self-harm over a 16 year period from 1996 until 2011 (n=11,802) but excluded persons with any previous hospital presentations for a suicide attempt in the year prior to the study commencement. Fedyszyn reported a similar if slightly lower one year risk of suicide of 0.9%. Even though these studies are based on large national populations, it must be noted that hospital presentations due to suicidal behaviours are under-recorded in Danish hospital registers.[35] A study found that only a minority (37%) of the suicide attempts were correctly coded with reason for contact code.[41]

Sweden: 1-year risk of suicide after deliberate self-harm

The review by Carroll et al. identified six Swedish mortality follow up studies that examined the one year suicide risk amongst suicide attempters[42-47], and since the publication of the review, two more mortality follow up studies[48, 49] reporting one year suicide risk estimates have been published. All of these eight studies were restricted to study populations consisting of individuals who were hospitalised due to a suicide attempt. Typically this is a more at

risk sub-group of the self-harm population whose episode of self-harm was severe enough to warrant in-patient care; hence this is why studies that are carried out on self-harm admissions populations may produce higher risk estimates than studies carried out on emergency department attendance populations. Three of the eight studies were carried out at a national level,[46, 48, 49] and the other five studies were sub-national studies restricted to populations from single centres or county level.[42-45, 47] The five sub-national studies were based on individuals who were admitted to hospital after a suicide attempt at various time periods during the eighties and nineties and showed a wide variation in the 1-year risk estimate of suicide, with three studies showing a one year suicide risk estimate of 1%-2%,[43, 45, 47] one study showing a one year suicide risk estimate that was just over 3%,[44] and the other study showing a one year suicide risk estimate that was in excess of 6%.[42] The three national studies,[46, 48, 49] also produced varying risk estimates. The earliest of the national mortality follow-up studies was carried out by Runeson et al.[46] on a cohort of 48,649 patients whose suicide attempt resulted in an admission to a psychiatric hospital over the time period 1973-1982 and found that the 1-year risk of suicide was 4.3%. The second national study by Tidemalm et al.[49] was based on a study population that consisted of 53,843 self-harm patients that were admitted to either a psychiatric or somatic hospital from 1990-1999 and showed that the 1-year risk of suicide was 2.1%. The most recent study by Runeson et al.[48] was also based on a study population of self-harm patients that were admitted to either a psychiatric or somatic hospital from 2000-2008 and found that the 1-year risk was 1.5%, which is similar if slightly lower than the estimate of 2.1%

from the study Tidemalm et al.[49] and much lower than the estimate of 4.3% from the earlier cohort by Runeson et al.[46] The differences in risk estimates may be due to differing population inclusion criteria across the three studies. The two more recent cohort studies were restricted to an inception cohort of self-harm patients i.e. individuals were excluded if they had any previous hospitalisations for self-harm in the 15 years before the study start date. The earlier cohort study from the seventies did not apply this criteria and therefore the study population may have consisted of a mixture of first attempters and repeat suicide attempters. It is widely accepted that individuals who engage in repeat acts of self-harm have an elevated risk of suicide, therefore the higher suicide risk estimates found in the earlier cohort may be due to the fact the study population consisted of a greater number of persons who engaged in repeat self-harm thus inflating the risk of suicide. Furthermore, another factor that may have contributed to the differing risk estimates is that the seventies cohort was restricted to suicide attempters that were admitted to a psychiatric hospital whereas the two more recent cohorts were based on populations that were admitted to either a psychiatric hospital or somatic hospitals. To conclude, the sub-national and national studies that have been carried out to date in Sweden have demonstrated a wide variation in the estimate of the one year risk of suicide after self-harm and this is probably due to differing inclusion criteria among the studies

Finland: 1-year risk of suicide after deliberate self-harm

In Finland, Carroll et al. identified four mortality follow up studies that examined the one year risk estimate of suicide after self-harm.[50-53] Only one of these studies by Haukka et al. was carried out at a national level,[50] the

other three studies,[51] [52, 53] were based on study populations from one or more hospitals. All four studies were based on self-harm patients that were admitted to hospital. The three sub-national studies were based on populations of self-harm patients admitted to hospital in Helsinki throughout the 1980s and 1990s showed that the one year risk of suicide ranged from 1.8% to 2.4%. The national study carried out by Haukka et al. was based on a more recent cohort of 18,199 patients that were admitted to hospital from 1997-2003; found that the one year risk of suicide was 3.2%. The authors of this study reported that 57% of the study population suffered from some form of a mental health disorder. It is plausible that this may have been a contributing factor to this high risk estimate of 3.2%, as it is widely accepted that people with mental health disorders are already at an increased risk of suicide.

Southern Europe 1-year risk of suicide after deliberate self-harm

To date relatively few mortality follow up studies of hospital treated self-harm patients have been carried out in Southern Europe. Carroll et al. identified one Italian mortality follow up study of self-harm patients that reported one year risk of suicide after self-harm,[54] and another Italian study was published in 2013.[55] Both of these were sub-national studies single centred studies. The first of the studies by Siani et al.[54] was based on 147 self-harm patents that were admitted to a psychiatric department during the seventies, and found that the one year risk of suicide was in excess of 3%. A more recent study by Pavarin et al.[55] was based 505 on individuals presenting to an emergency department between 2004 and 2010 in Bologna and showed that the one year risk of suicide was 2.3%. In Spain a single centred study

published in 1999 based on 150 individuals who attempted suicide and were admitted to a psychiatric department found that the one year risk of suicide was almost 4%.[56] It must be noted that both of these Italian and Spanish studies were based on relatively small sample sizes and hence may not have been large enough to provide accurate estimates of suicide risk.

Australia and New Zealand: 1-year risk of suicide after deliberate self-harm

Carroll et al. identified only one Australian study carried out on 223 self-harm patients who presented to a hospital in Sydney from October 1975 until September 1976, the findings showed that the one year risk of suicide was 1.7%.[57] A more recent study carried out on a very large cohort of 54,393 self-harm patients admitted to hospital across two Australian states from 2000 until 2009 found that the six month risk of suicide was 0.5%.[58] Although this study did not follow up the self-harm patients for the clinically important one year time period, the findings of this study are worth mentioning as this study is the largest of its kind to be conducted in Australia to date. In New Zealand, no national mortality follow up cohort study of self-harm patients has been conducted, instead single centre studies have been carried out. Carroll et al. found only two sub-national studies have been carried out in New Zealand. One cohort study examining 754 patients presenting to hospital with self-harm in Auckland from January 2001 until August 2002 showed that the one year risk of suicide was 1.1%.[59] Another larger study carried out over ten year period from 1993-2002 amongst 3,690 self-harm patients that were admitted to hospital in Christchurch found a similar if slightly higher one year risk of 1.4%.[60]

North America: 1-year risk of suicide after deliberate self-harm

In North America few longitudinal studies examining the risk of suicide in the hospital treated self-harm population have been conducted, furthermore no studies have been carried out a national level. Carroll et al. identified only one Canadian cohort study published in 1990, which found that the one year risk of suicide among 228 self-harm patients was 1.7%.[61] Carroll et al. did not identify any cohort studies that were carried out in America. However, in 2013, a cohort study by Miller et al. [62] was published, this study was based on New Jersey hospital discharge data, and although this study did not report a 1-year suicide risk estimate, the overall risk of suicide over the five year follow up period from 2003-2007 was 1.3%.

Asia 1-year risk of suicide after deliberate self-harm

In Asia there has been a paucity of research investigating the risk of suicide in the self-harm population. However, in recent years the number of such studies has been increasing. Carroll et al. identified two separate cohort studies carried out in different locations in Taiwan.[63, 64] The first study, was a small study, conducted on a 145 self-harm patients that were admitted to the emergency department of a medical centre in central Taiwan, showed that the one year risk of suicide was 3.4%.[63] The second study, was a conducted on a larger cohort of 7,601 self-harm patients who presented to accident and emergency departments in Tapei over the period 2004-2006 found that the one year suicide risk was 1.6%.[64] In 2013, another suicide mortality follow up study was published.[65] This study was based on a sample of 3,299 patients from across accident and emergency departments in Tao-Yuan County in Northern Taiwan over the period 2006-2008, and found that the

one year risk of suicide was 1.5%. In 2016, the findings from the first nationwide study of 55,560 hospital presenting self-harm patients in Taiwan was published.[66] Although this study did not calculate one year suicide rates, it did report that over a three year follow up period from 2006-2008 the risk of suicide was 1.5%.

In China, such studies are limited because follow-up with hospitalized suicide attempters is generally lacking. Carroll et al. identified one small Chinese study of 100 suicide attempters who presented to hospital and found the one year risk of suicide was just over 1%.[67] From my search of the literature from 2013 onwards no additional Chinese studies were found.

My literature review also identified one other Asian study carried out in Japan, this Japanese mortality follow-up study was published in 2013, on a sample of 66 overdose patients admitted to hospital and found that 3% (2/66) had died within one year.[68] This is the first study of its kind to be carried out in Japan. Caution should be taken when interpreting these findings as the study has a number of methodological problems; such as small sample size that consisted of a highly selected sub group of self-harm patients furthermore the study had poor methods for detecting suicide during follow-up.

Summary of Literature Estimating the 1-year estimate of suicide risk

The systematic review by Carroll et al. provides the most reliable and up to date international estimate of the one year risk of suicide after self-harm (1.7%, 95% CI 1.3-2.3). My literature research has shown that research in this area has grown to include studies that are based on substantially large

cohorts of hospital treated self-harm patients with the emergence of cohort studies from Asia. Nonetheless, internationally, research in this area is still hindered by the fact that few countries have national recording systems for hospital treated self-harm. As a consequence, the majority of research in this area has been based on self-harm populations from single centres or regional multi-centres, however a small number of emerging studies have been carried using national cohorts of hospital treated self-harm patients. These national studies have been mainly carried out in Nordic countries, Denmark, Sweden, and Finland. However, in Taiwan, the establishment of the National Suicide Surveillance System (NSSS) in 2006, has facilitated a national mortality follow up study of self-harm patients to be carried out. All of these national studies have reported a wide variation in the estimation of the risk of suicide after self-harm. This in part may due to the fact that the epidemiology of suicidal behaviours may vary among populations from different countries. Differing study methodologies may also be a factor. For example, some of these studies are limited to populations of persons that presented to hospital following self-harm, not just those who were subsequently admitted to hospital. This is important, as it has been suggested that there are compositional differences between hospital admission based samples and self-harm hospital attendance samples, as the self-harm cases that lead to inpatient hospital admission are often seen as more serious self-harm cases engaging in more lethal methods of self-harm. Moreover, some of these studies have examined an individual's last act of self-harm; whereas others have examined the index episode of self-harm. It

has been suggested that studying an individuals' last act of self-harm is more relevant to the subsequent death than the first (index) episode of self-harm.[27]

To conclude, much of the research examining the association between self-harm and subsequent risk of suicide has been dominated by studies from Nordic countries, with a distinct lack of studies from southern Europe and North America. To date no research in this area has been carried out in the Republic of Ireland, despite the fact that Ireland has a national Registry that records all hospital due to self-harm. Extrapolating estimates of the risk of suicide after self-harm from one country and applying them to another country may not be appropriate as the characteristics of the self-harm patient populations may vary across countries as do differences in general population levels of suicide. This highlights the need for research to be carried out at a national level in the Republic of Ireland to determine the risk of suicide after self-harm.

Chapter 3

Record Linkage Methodology

Overview of Record Linkage

This section describes the methods and procedures used to link two data sources together namely, the National Registry of Deliberate Self Harm (NRDSH) data and the Central Statistics Office mortality data, to enable the calculation of the risk of external cause mortality in a national cohort of hospital treated deliberate self-harm patients. This chapter will begin by providing a brief introduction to the history, theory and practice of record linkage in epidemiological research. The data sources used in this study and the methods used to link them are then described in detail. A critical appraisal of those methods and discussion of the weaknesses and potential sources of bias in the linked data set is provided.

Definition of record linkage

Record linkage can be defined as the process of bringing together two or more separately recorded pieces of information that belong to a particular individual[69] or family, event or place.[70] Record linkage can also be defined as combining different records that come from different sources but belong to the same person into one record.[71] Record linkage is the science of finding duplicates or matches within or across data-files. In record linkage matches are typically defined using name, address, and date-of-birth information.[72] In recent decades record linkage methodologies have been developed across many differing fields for various purposes and applications.

History of record linkage

The majority of the early work in record linkage was conducted in the field of health. Medical record linkage techniques can greatly enhance research by

providing answers to public health or clinical questions by bringing together data from different sources.[73] The benefits of applying record linkage in the field of health were first recognised by the Chief of the US National Office of Vital Statistics, Halbery Dunn. Dunn was the first to use the term record linkage and advocated the use of a unique number (e.g. birth registration number) to facilitate such linkages. Dunn stated that:

"*Each person in the world creates a Book of Life. This Book starts with birth and ends with death. Its pages are made up of the records of the principal events of life. Record linkage is the name given to the process of assembling the pages of the book of life*".[69]

Historically record linkage was a manual process that was carried out by clerks who would search and review paper based lists to bring together the appropriate pairs of records for comparison and if necessary obtain additional information when there were questionable matches, and finally make decisions regarding the linkages based on established rules. Advancements in the field of record linkage was hindered by the fact that information or data was often recorded in relatively inaccessible formats and even when circumstances were favourable, as in the case of census data and registrations of births deaths and marriages data, there was little recognition of the potential of such data being brought together so as to relate the successive events in the lives of particular individuals and families. However, in the late 1950's, Howard Newcombe, an expert in the field of record linkage techniques, was the first to report how the use of computers could greatly improve and advance record linkage techniques. Newcombe showed that computers had on the ability to link medical records and vital

statistics records that were contained on punch cards at a rate of about 10 per minute.[74] By the late 1970's, Newcombe demonstrated the enormous potential and superiority of computerized record linkage over record linkage based on human clerical review, particularly for large studies.[75]

To date, record linkage has been conducted across diverse fields in health research such as dental health[76], injury research[77], diabetes research[78] and cancer research.[79] Data linkage systems for health services research have been set up in countries such as the United Kingdom, Canada, the United States, Australia and the Nordic countries. In the United Kingdom, the Oxford Record Linkage Study (ORLS) was established in 1963 to link vital records (birth and death registries) with primary care and hospital admission data. In Canada, examples include, the Manitoba Population Health Information System and the British Columbia Linked Health Database which links a wide range of data including, vital records, pharmacy purchases, clinical data from electronic medical records and cancer registry data. In the United States, the Rochester Epidemiology Project is a linkage system that has been collecting the medical records of all residents of Olmsted County, Minnesota since 1935. The Western Australia Data Linkage System (WADLS) is an example of large successful data linkage system that has been linking over 30 different datasets over the last 40 years. In Denmark, Norway and Sweden, the linkage of individual level data is carried out routinely. At birth, in these countries, an individual is assigned with an identification number which is unique and permanent. The use of such an identification number allows individuals to be easily identified in record linkage.

Types of record linkage

There are broadly two types of record linkage, deterministic record linkage and probabilistic record linkage. Deterministic record linkage requires matching variable(s) to agree exactly across record pairs (i.e. exact one-to-one character matching) in order to be considered a match. However, any coding errors in the matching variables may result in some true matches being missed. Furthermore, deterministic record linkage does not take into consideration the discriminatory power of matching variables,[80] for example certain matching variables such as date of birth have a greater ability to identify an individual compared to other matching variables such as gender. Choosing the appropriate linkage technique depends on many factors such as time, resources, the research question and most importantly the quantity and quality of the matching variables that are available to use.[80] Deterministic record linkage is generally best used when a single unique identifier (such as a social security number or NHS number), or high quality matching variables are available. However, unique identifiers are rarely available and real world data often contains missing information, typographical and data entry errors. Probabilistic record linkage offers an alternative method, as it works well with fewer identifiers and allows for some errors between identifiers, which can lead to much better linkage than simple deterministic record linkage methods.

Overview and introduction to probabilistic data linkage

The basic ideas of probabilistic record linkage was first proposed by Howard Newcombe in 1959[74] while the theoretical underpinning was developed by

Felligi and Sunter.[71] Probabilistic data linking is concerned with assessing the similarity of identifiers or matching variables of a record within one file with the similarity of matching variables of a record in another file, to determine, based on the use of probabilities, whether two records are a true match given the agreement or disagreement of specified matching variables. Pairs of records compared between different files are called comparison pairs. A match is when records belong to the same person, and a non-match is when records belong to different individuals. In probabilistic record linkage, a formula is used to generate a number referred to as a "match weight" for each comparison pair of records. This number reflects the probability that the records refers to the same individual.

The basic concepts and processes involved in probabilistic data linkage will be briefly introduced here, while the actual steps and procedures undertaken in the probabilistic record linkage of the self-harm Registry data and the national mortality data will be described in detail in the subsequent sections. The main stages involved are as follows, the pre match data preparation (de-duplication of linkage files, the selection of matching fields, cleaning and standardisation of matching fields), blocking (this involves forming a set of comparison pairs by bringing together records from the files that are to be linked) and the comparison and classification of record pairs (this involves comparisons between pairs of records, the calculation of match weights and setting of pre-defined cut-off points to classify comparison pairs as being matches or non-matches).

An introduction to the pre-match data preparation

The starting point of any record linkage project is the pre-match data preparation step. The quality and success of record linkage is dependent upon the quality and completeness of the underlying data. Therefore, adequate and sufficient data preparation is fundamental to any data linkage project.

A set of data fields or variables that are common to both files need to be identified and selected in order to form the basis for the matching of records between the two files. Linkage fields or matching fields are a set of pre-selected variables that are common to both files; these variables help to describe the characteristics of an individual. In the absence of a unique personal identifier, a combination of quasi-identifiers may be used. The term "quasi-identifier" was first coined by Dalenius[81] and refers to data fields that reveal some information about an individual, but not necessarily enough to uniquely identify an individual. Quasi-identifiers are variables related to the general information about a person (e.g. name, date of birth, gender and address). Ideally quasi-identifiers should have a low level of error and have high discriminating power. However, often the choice is based on availability rather than the data quality or discriminating power.

Data cleaning is necessary to ensure that differences in the recording procedures across the files to be linked do not affect the quality of the record linkage. In addition to cleaning, the data needs to standardised in the same way so that comparisons can be accurate. In keeping with the basic steps of probabilistic linkage using the Fellegi-Sunter-Winkler-Jaro model, the matching fields in File A and File B should be standardised so that they

share a common format. For example, if gender is recorded in free text format i.e. “Male” or “Female” in File A, but in File B it is recorded in numeric format “1” or “2” in file B, then the values on File A need to be transformed to match those in File B.

Furthermore, depending on the types of files that are to be linked i.e. are individuals recorded only once in the file (death registrations) or are the individuals recorded more than once in the file (hospital admissions data), it may be necessary to de-duplicate the files to ensure that any duplicate or superfluous records are removed.

An introduction to blocking

In theory one could compare every record in File A with every record in File B. However, this is often unproductive and impractical because even when linking small files the majority of comparison pairs will not be matches. Therefore, typically a subset of comparison pairs that meet certain basic criteria are evaluated. This is done by using a technique called ‘Blocking’. Blocking requires that two records agree exactly on specific identifier(s).[82] For example, if date of birth is chosen as a blocking variable, all records that have the same date of birth in the File A and File B are linked together regardless of whether the records match on other identifiers. Typically multiple blocking passes are carried out using different identifier variables so that records that were not blocked together in one blocking pass have the potential to be blocked and compared in another pass, thus avoiding automatic misclassification.[80]

An introduction to the comparison and classification of record pairs

Comparison specification

This step is concerned with specifying how the comparison pairs generated from the multiple blocking passes are to be compared on each matching field. With the Felligi and Sunter probabilistic record linkage framework [71] this step results in the calculation of a comparison or similarity vector for each matching field within a comparison pair.[83]

A comparison or similarity function measures the similarity of each set of pre-selected matching fields within a comparison pair of records. The most widely used comparison function is the exact comparison function as proposed by Jaro [84] which consists of only agree/disagree (1/0) values. If there is agreement between a comparison pair with respect to a matching field then a value of 1 is assigned in the vector but if the pair of records disagree on the matching field then 0 is assigned. In certain cases, the comparison function can be extended beyond the simplistic exact comparison function to include a string comparator function which returns a value between 0 and 1 depending on the degree of agreement of the two strings fields.[83]

The vector produced for each comparison pair of records based on the exact comparison function for each matching field has 2n possible values or agreement patterns, where “n” is the number of matching fields. For example, if record linkage was carried out using just three matching fields, the comparison vector would have these eight possible agreement patterns:

[0,0,0] [0,0,1] [0,1,0] [1,0,0] [0,1,1] [1,0,1] [1,1,0] [1,1,1]

String fields such as forename, surname and addresses can be prone to typographical variation and errors. For this reason, record linkage techniques need to apply effective string comparison functions to deal with typographical errors and differences in naming conventions. Distance function is an example of string comparator function that determines how many steps (insertions, deletions, transpositions, etc.) are required to get from String A to String B.[80] Examples of other string comparator functions used in record linkage include, Soundex, the Jaro-Winkler Comparator and the Q-gram Based String Compartors.

Validation of comparison records

Validation of comparison records generally involves seeking additional information from other sources in an attempt to resolve the question of whether two records refer to the same person i.e. establish the true match status for a comparison pair of records. If it were possible to obtain and review such additional information for all possible comparison pairs in a record linkage study then the record linkage process would be redundant. However, in general it is only feasible to access and review such information for a subset of cases. This subset should be large enough to contain a number of instances of a wide variety of agreement patterns.

Match Weight calculation

The Fellegi and Sunter method consists of generating a match weight for each comparison pair.[71] The match weight represents the likelihood of matching variables agreeing given the true match status of the comparison pairs. The match weight is widely considered the most powerful test of

whether any two records are a true match.[85] The match weight is calculated by getting the logarithm to the base two of a ratio between two probabilities, the M-probability and the U-probability (log2(m/u)). The calculation of the U-probabilities and M-probabilities is at the heart of record linkage.[86] The U-probability is the probability that a matching variable agrees purely by chance for a comparison pair of records that do not belong to the same person i.e. not a match. The M-probability is the conditional probability of an agreement on a given variable if the record pair is a true match. The calculation of the U-probabilities and M-probabilities and the corresponding weight is repeated for each of the matching variables, and the total weight for a comparison pair is derived by summing the (dis)agreement weights for each of the matching variables.[86] Matching variables that agree contribute positively to the match weight and matching variables that disagree contribute negatively to the match weight of a comparison pair. Not all matching variables contribute the same weight, the size of the contribution depends on the discriminatory power of the matching variable (e.g. agreement on surname contributes more than agreement on gender). Furthermore, the size of the contribution can also depend on the frequency of individual values of a matching variable. Taking surname as an example, less common surnames such 'Zhu' contribute more to the overall weight more than more commonly occurring surnames such as 'Murphy'.

While algorithms used to calculate the match weights involve some complexity, there is concern in the field of data linkage that over-elaboration or excessive complexity be avoided as it has been argued that there are diminishing returns beyond a certain level of refinement.[87]

Setting cut-off threshold for match weights and classification of comparison pairs as matches or non-matches

This step involves classifying comparison pairs as either being definite matches if the match weight is above the cut-off point, non-matches if the weight is below the cut-off point and possible matches if the weight is between the cut-off points. In reality it is not possible to know exactly which comparison pairs are true matches and true non-matches, rather we just observe the combined number of comparison pairs at any given match weight observed match weights. Nevertheless, the establishment of an appropriate cut-off weight/threshold is an important part of the linkage process.[88] The choice of a cut-off threshold cannot be done on an arbitrary basis, however, it is far from being an automatic task *as a certain degree of "art" or "fiddling around" with the linkages will be necessary despite mathematical and technological advances.*[77] One approach is to select a subset of comparison pairs that have been validated/clerically reviewed and devise a set of decision rules based on that subset, and then apply such rules to the remaining comparison pairs.

Probabilistic record linkage of the self-harm Registry data with the national mortality data

Data sources - The national registry of deliberate self-harm

The National Registry of Deliberate Self Harm (NRDSH) Ireland records all self-harm presentations made to each acute hospital across the Republic of Ireland. The Registry is operated by the National Suicide Research Foundation (NSRF) and funded by the Irish Health Service Executive's (HSE) National Office for Suicide Prevention (NOSP).

The self-harm Registry uses the following as its definition of deliberate self-harm:

> *'an act with non-fatal outcome in which an individual deliberately initiates a non-habitual behaviour, that without intervention from others will cause self-harm, or deliberately ingests a substance in excess of the prescribed or generally recognised therapeutic dosage, and which is aimed at realising changes that the person desires via the actual or expected physical consequences'.*

This case definition of self-harm was one that has been developed by the former WHO/Multi-centre Study on Parasuicide and has been widely applied in research.[89] Internationally, the term parasuicide has been superseded by the term 'deliberate self-harm' and consequently, the Registry has adopted the term 'deliberate self-harm'. The definition includes acts involving varying levels of suicidal intent and various underlying motives such as loss of control, cry for help or self-punishment.

Data items recorded by the self-harm Registry include: patient gender, age, area of residence coded to administrative area (district electoral division) and county level, date and hour of attendance at hospital, method(s) of self-harm, drugs taken (if applicable), and recommended next care. Method(s) of self-harm were classified according to the Tenth Revision of the WHO's International Classification of Diseases codes for intentional injury (X60–X84). The Registry seeks to ensure patient anonymity while at the same time enabling repeat self-harm presentations by the same patients to be linked. The Registry does this by creating a patient code for each self-harm record. This code is generated by selecting specific letters from the patient's name, generating a numeric code for these letters and combining this code with a code generated from the patient's date of birth and a code generated from the patient's sex. This patient code is stored in the Registry database. The patient name is not stored nor can it be created or extracted from the patient code. The patient code is used to distinguish between self-harm patients and to identify repeat presentations by the same patients. The Registry does not collect data on employment status, marital status, suicide intent or psychiatric diagnosis. Self-harm data are collected by dedicated data registration officers who operate independently of the hospitals and there is standardised application of case definition and inclusion/exclusion criteria. All data registration officers receive standard training in the Registry data collection methods and procedures and attend biannual update meetings which review case definitions and related quality control issues.

For this data linkage study, self-harm data for both males and females of all ages for the years 2009-2011 were extracted from the self-harm Registry.

Data sources - External cause mortality data

The Irish Central Statistics Office (CSO) provided on-site access to data relating to all deaths by external cause (codes V01– Y98 of the Tenth Revision of the International Classification of Diseases, Injuries and Causes of Death ICD-10) that occurred during the years 2009 to 2011. External cause death data for both males and females aged 7 years and older were retrieved. External cause deaths, are deaths that are not due to illness or disease and consist of accidental falls, drownings and poisonings, suicides, road traffic accidents and homicides. For the purpose of this study, deaths of undetermined intent (Y10-Y34) were combined with suicide deaths (X60-X84) (as is common practice in suicide research) and from herewith shall be referred to as suicide deaths. The principal variables collected included, personal identifers such as name, date of birth gender, and address, sociodemographic characteristics such as marital status, social class, employment status, occupation, domestic living arrangements and details relating to the actual death such the cause of death, the date of death, the date of registration and the place of death.

In Ireland, deaths due to external causes are referred to coroners and result in inquests, these deaths are not registered until the inquest has been held and this typically occurs within six to twelve months after the death.[4] However, in some cases registration may occur over a year after the death. The CSO publishes official annual reports of all deaths that occurred in a particular year. Only deaths registered in the calendar year they occurred, or registered in the next calendar year, are included in these official annual statistics reports, any deaths registered after this date, are included in a late

deaths data file instead. For this record linkage study, all external cause deaths in person aged seven years and older that occurred in the years 2009-2011 and were registered up until end of 2012 were included.

Ethical Approval and Data Access Permissions

Ethical approval for the data linkage was received from the Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC) (Appendix 1). The General Register Office (GRO) granted approval for the mortality data to be accessed for data linkage purposes (Appendix 2). Irene O'Farrell the investigator/researcher was granted Officer of Statistics status by the CSO to complete the data linkage project. This work was completed by Irene O'Farrell as part of her PhD studies at the University College Cork (UCC) under the supervision of Professor Ivan Perry Head of the Department of Epidemiology and Public Health UCC and Dr Paul Corcoran of the National Suicide Research Foundation and UCC. Ethical approval for the self-harm Registry was granted by the Irish National Research Ethics Committee of the Faculty of Public Health Medicine. The National Suicide Research Foundation is registered with the Data Protection Agency and complies with the Irish Data Protection Act of 1988 and the Irish Data Protection (Amendment) Act of 2003. Following signature of a confidentiality undertaking, the National Suicide Research Foundation assigned Irene O'Farrell data registration officer status for the duration of the data linkage project.

Methods used to ensure confidentiality of data

The self-harm data collected from emergency department records were encrypted. Confidentiality of the self-harm data was strictly maintained and

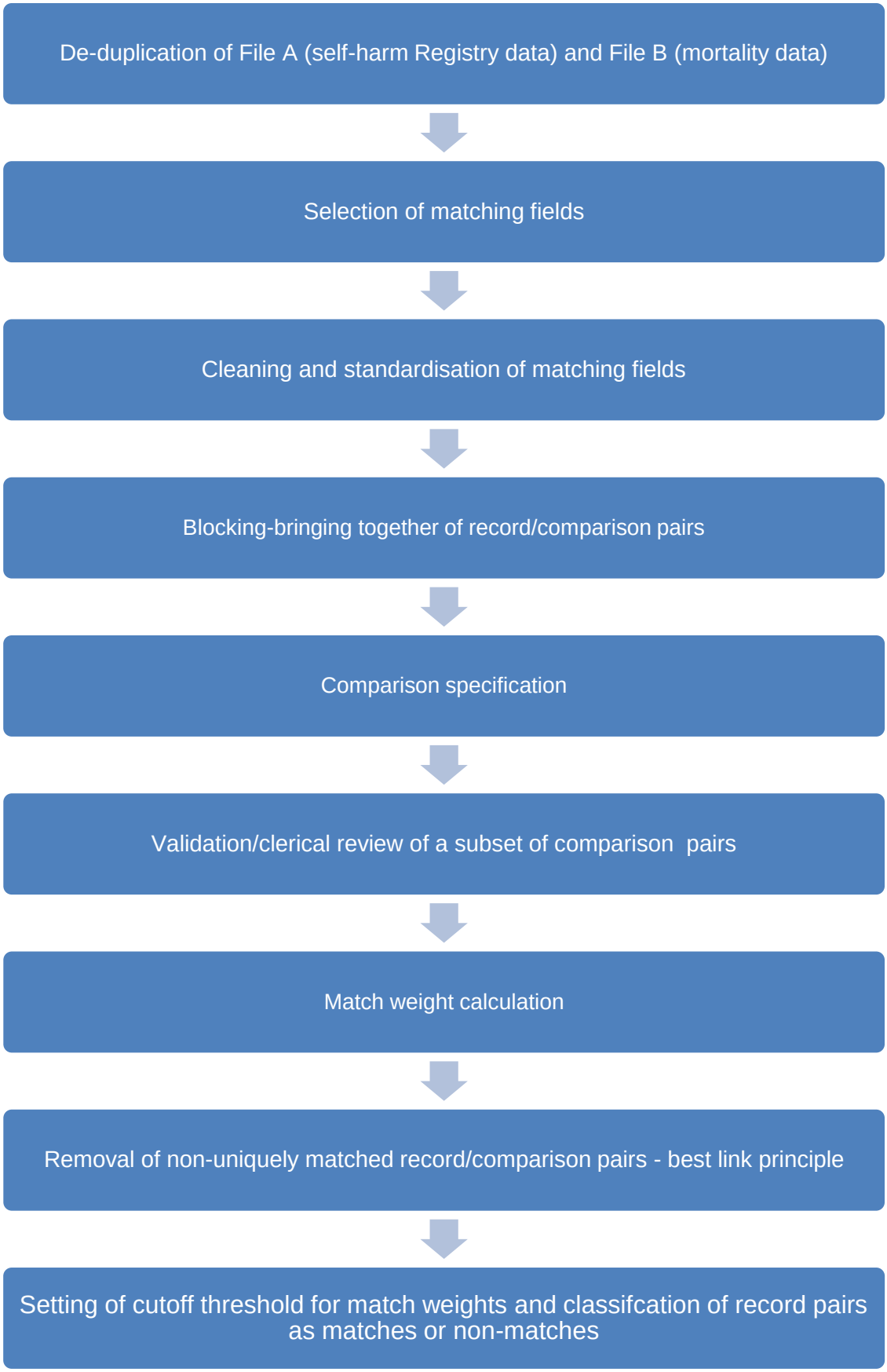
the data were stored on a password protected laptop and kept in a supervised location at all times. The linkage of the datasets was carried out on a secure computer on-site in the CSO in Cork. The co-investigators were made Officers of Statistics by the CSO. This involves signing a declaration to observe all the requirements of the Statistics Act, 1993. To protect the privacy of individuals, after the record linkage was completed, personal identifiers were removed from the linked dataset before analysis of the data was carried out.

Probabilistic Record Linkage Process

This record linkage study has applied the classical probabilistic record linkage theory as proposed by Felligi and Sunter, the application of the Felligi and Sunter principles have been somewhat tailored to suit the nature of the two datasets to be linked for this this thesis. The previous section briefly introduced the broad stages involved in data linkage, in the next sections, the actual steps performed during the linkage of the self-harm and mortality files will be outlined. The first three steps include the pre-match data preparation, (1) the de-duplication of the two data files that are to be linked, (2) the selection of matching fields and (3) the cleaning and standardisation of the matching fields, (4) blocking, (5) comparison specification, (6) validation/clerical review of a subset of comparison pairs, (7) the calculation of the match weights, (8) the removal of non-uniquely matched record pairs and lastly (9) the setting of match weight cut- off thresholds and classification of comparison pairs as matches or non-matches.

A flow diagram of the record linkage process is described in Figure 3.1

Figure 3.1 Flow diagram of the record linkage process



De-duplication of the data files

De-duplication is performed as an internal record linkage process within each dataset. Removing duplicates results in files with a single record for each represented person which simplifies the subsequent record linkage process performed between the files.

De-duplication of the mortality data

Given the once-ever nature of death, mortality data files should only contain a single record for each deceased person. Each record in the CSO mortality file had a unique reference number assigned when the death was registered. A check for duplicate reference numbers was carried out and no duplicate numbers were found. However, it is conceivable that, in error, a death may have been registered twice, resulting in the mortality data file containing two records with different reference numbers representing the same death. The mortality data were checked for duplicate death records using the following identifying fields: forename, surname, date of birth, date of death, gender and address. This was done using the LinkPlus software. LinkPlus is freely available record linkage program developed by the Centre for Disease Control (CDC). LinkPlus is a powerful, user-friendly record linkage software package that has the capability of detecting duplicates within a single file by blocking comparing and scoring records in the same file against each other. LinkPlus then produces a ranked list of record pairs based on the match scores of the records, the assumption being that high scoring pairs may be duplicates. It is assumed that there will be a minimal number of duplicate deaths owing to the fact that this is official published mortality data so therefore only high scoring pairs were examined. In all it was that there were

29 duplicate death registrations. These duplicates were then removed from the mortality file before the linkage was carried out.

De-duplication of the self-harm data

Unlike the mortality file, the self-harm data may contain multiple records for individual self-harm patients because a considerable proportion of self-harm patients repeat the behaviour and present again to hospital. As described above, the self-harm Registry assigns a code to each self-harm patient. Using the patient code, repeat self-harm presentations during the study period 2009-2011 were detected in the self-harm file. In instances where a patient was associated with multiple self-harm records, the record associated with the last hospital presentation during the study time period (2009-2011) was used for the data linkage.

Selection of matching fields

In Ireland, there is no unique personal identifier used across the health and vital statistics systems. The following quasi-identifiers, common to both the self-harm Registry data and the mortality data, were selected as the matching variables: forename, surname, date of birth, gender and area of residence. To preserve the anonymity of the self-harm patient, an individual's full text address is not recorded; instead the self-harm patient's area of residence was coded to an administrative area, known as a district electoral division (DED). DEDs are a much smaller and finer scale geographical area than county and therefore would possess a greater discriminative power to identify an individual than county of residence. However, it was decided that county of residence would be a more stable variable to use as a linkage

variable than DED. The main reasons being, that any errors in geocoding of address data would most likely result in the incorrect DED being selected rather than county, additionally, a change in residential location would most likely result in a change in DED than county. However, as DED area of residence contained very valuable information it was decided that it would still be used as additional identifying information at the comparison and classification stage of the linkage process. Table 3.1 outlines the matching variables used in this study and the variation in the extent to which the variables were recorded and their format in the self-harm Registry data and mortality data.

According to Fellegi and Sunter principles, the best matching results are obtained if data fields are broken down or parsed into the smallest atomic data elements possible. Therefore patient forename and surname were considered as separate matching fields as were day, month and year of birth.[80]

Table 3.1 Matching variables used in record linkage

Matching Field	Format in self-harm Registry data	Format in mortality data
Forename	Selected letters encoded Format: Numeric variable • Only first two letters of forename recorded and encoded into numerical code	Full text forename (free form) Format: Text variable - • May include nicknames, synonyms, prefixes, suffixes, punctuation, spaces, initials and transposition errors
Surname	Selected letters encoded Format: Numeric variable - • First two letters of surname recorded and encoded into numerical code • If surname is double barrelled - first two letters of both the first surname and second surname recorded and encoded into numerical code • If surname has prefix such as 'Mc' 'Mac' 'O' etc. - all of the letters in prefix are recorded and encoded in addition to the first two letters after the prefix	Full text surname (free form) Format: Text variable - • May include second surnames, synonyms, prefixes, suffixes, punctuation, spaces, initials and transposition errors
Date of birth	Format: Date variable (DD/MM/YYYY) day, month , year of birth	Format: Date variable (DD/MM/YYYY) day, month , year of birth
	Format: Numeric variable • Male =1, Female=2	Format: Text variable • 'Male' 'Female'
Area of residence	County of residence Format: Numeric variable but different county coding systems used *(Full text address not recorded but area of residence was coded to a smaller geographical area than county - district electoral division area – this was not used as matching field)*	County of residence Format: Numeric variable but different county coding systems used *(Although full text address was recorded - this was not used as matching field)*

Cleaning and standardisation of matching fields

Forename matching field

As mentioned previously, the self-harm Registry does not record a self-harm patient's full text forename, instead the Registry uses software is used to encode selected letters of the forename into a numerical code. Therefore, limited data cleaning could be done with these encoded data. Data cleaning of the forename field in the mortality file involved the identification and removal of any prefix, suffix, punctuation or trailing spaces. In addition, the forename data field was examined for transposition errors, i.e. obvious instances where a surname might have been erroneously entered in the forename field. Any second forenames names found in the forename field were separated out into an additional field for comparison.

Also, forenames were linked to an array of synonyms known as a nickname lookup. A nickname lookup contains common nicknames and diminutive names for given names. For example, this would allow the name "Elizabeth" and "Liz" to be considered as the same forename so that a person recorded as "Elizabeth" in File A and "Liz" in File B would be recognised as having the same forename, potentially allowing these records to be brought together.

After this cleaning process was completed, the forenames, second forenames (where available), the substituted nicknames derived from the nickname look were all encoded to a numerical code using the self-harm Registry's software.

Surname matching field

As mentioned previously, the self-harm Registry does not record the patient's full text surname; instead software is used to encode selected letters of the surname into a numerical code.

If a self-harm patient has a double barrelled surname, then letters from the first and from the second surname are selected and encoded and recorded together in one data field. However, as record linkage works best when fields are broken down into sub components, the encoded initials from the first and second surname were parsed out into two separate fields.

If a self-harm patient's name contains a prefix such as "O" or "Mc" before the surname then the letters in the prefix are encoded in addition to the selected letters of the surname itself. Unfortunately, maiden names are not recorded by the Registry.

In the surname field in mortality file, any punctuation or trailing spaces were identified and removed. Additionally, the surname fields in the mortality file were examined for transposition errors i.e. obvious instances where the forename might have been erroneously entered in under the surname field. If the surname was found to be double barrelled, then the two surnames were parsed out into separate fields. Additionally, for females, any maiden names (identified by the use of the term 'nee') were also parsed out into separate fields. However both marriage names and maiden names may not always be recorded for all female mortality cases. After, the cleaning process was completed, all surname fields in the mortality file were encoded to a numerical code using the self-harm Registry's software.

It must be noted that there is the possibility that some potential matches may be missed in females because maiden names and married names may not have been recorded consistently across the Registry and mortality files.

Date of birth matching field

Date of birth and age are captured in both the self-harm Registry data and the mortality data, but the completeness in the recording of date of birth differed across the two files. Date of birth was recorded for every case in the self-harm Registry data, however in the mortality file age was recorded for every death but the full date of birth was missing for 18% of cases overall (2009=22%, 2010=18% and 2011=14%). For these cases the year of birth was calculated by subtracting age from the year of death and allowances were made for the fact that age may be off by one year. Therefore, a tolerance parameter of minus one year was applied to cases where year of birth was reckoned by subtracting age from year of birth.

In the self-harm Registry file and mortality file, date of birth was parsed into three separate fields, day of birth, month of birth and year of birth. In both the self-harm Registry file and mortality file, the age field was checked for unrealistic values e.g. 150 years olds. Possible errors in the date field were examined by carrying out checks to ensure that no day of birth had a value greater than 31 and no month of birth had a value of greater than 12.

Gender matching field

Currently there is no failsafe way to check that gender is not misrecorded. Lookups that map forename to a gender can be used; however these are mainly based on anglicised names and may not be suitable for an Irish

population. Instead the gender field in the mortality data was examined for inconsistencies by “eyeballing” the forename for each record and making sure that there was no obvious errors such as a record with the name ‘John’ being record as female. However, it must be noted that gender is usually reliable and does not tend to have many recording errors.[88] It was not possible to do the consistency checks for gender in self-harm Registry data using this eyeballing method because the full text version of the forename is not recorded, only a numerical code is available.

In self-harm Registry file, gender was recorded as a numerical code, however in the mortality file gender is recorded in text format. Therefore, the gender field in the mortality data had to be transformed to the same numerical coding system as the Registry data.

County of residence matching field

Although county of residence was the matching variable used to denote the area of residence for both the self-harm cases and mortality cases, as discussed previously, other address information was also recorded in both the mortality file and self-harm Registry file. However, this additional address information was not recorded in a similar format. For example, in the mortality file, the full text address was recorded but in the self-harm file the patients’ address was coded to district electoral division (DED). In the Republic of Ireland there are a total of 3,409 DEDs. According to the 2011 Census, DEDs had a mean population of 1,346 and ranged in population size from 73 to 36,057.

In order to make comparisons, this address data needed to be standardised so the address information in the mortality file needed to be assigned to a corresponding DED area. Unlike countries such as the United Kingdom, Ireland did not have postcodes during the study period making the geocoding of address data a less than straightforward task. This process of geocoding was carried out using the GeoDirectory database which provides a list of official postal addresses and location details for every residential and commercial property in the Republic of Ireland. For some mortality records, the address information lacked sufficient detail to be assigned to one specific DED (Irish addresses outside of cities tend to have a high level of ambiguity and often roads and streets can span multiple DEDs). As a consequence, an ambiguous address could be assigned to more than one DED. In these instances all of these associated DEDs were recorded.

Blocking - Process of bringing together record pairs

Comparing every record in the self-harm file with every record in the mortality file would have involved 26,168 × 5,288 = 138,376,384 comparison pairs. This is an overwhelming large number of comparison pairs to evaluate and instead a blocking scheme was devised. This blocking system assumed that records not agreeing on any of these blocking variables did not belong to the same person.[90] Multiple blocking passes were carried out using different identifier variables as detailed in Table 3.2. In total 15,350 comparison pairs were produced from this multiple iterative blocking scheme.

When using multiple blocking passes one can decide to (1) only link unmatched records from both files in subsequent blocking passes which can be quite a restrictive approach or (2) include previous linked records in

subsequent blocking passes which is a less restrictive approach.[82] In this record linkage the former approach was applied. Each iteration of the blocking scheme resulted in a set of linked records from both files (comparison pairs) and a set of unlinked records. After each iteration the next iteration began afresh considering all the records. Previously linked records were not excluded from subsequent blocking passes in order maximise the number of possible comparison.

Blocking was carried out using both LinkPlus and STATA software packages. LinkPlus allows a one to many relationship between File A and File B, and STATA allows a many to many relationship between File A and File B. Typically in record linkage, the larger file is assigned as File A, in this case the self-harm Registry file. A one to many relationship means that one self-harm record can link to more than one mortality record and a many to many relationship means that many self-harm harm records can link to many death records. LinkPlus, a freely available record linkage program developed by the Centre for Disease Control (CDC), was only used as a means of bringing to together comparison pairs of records. The last step of blocking involved the comparison pairs from each block being combined into one file in STATA prior to the next step of the linkage process.

Table 3.2 The multiple blocking passes used in the record linkage

Block 1 Using Link Plus: Extract and compare pairs that agree on forename initials
Block 2 Using Link Plus: Extract and compare pairs that agree on surname initials
Block 3 Using Link Plus: Extract and compare pairs that agree on gender
Block 4 Using Link Plus: Extract and compare pairs that agree on date of birth
Block 5 Using Link Plus: Extract and compare pairs that agree on year of birth
Block 6 Using Link Plus: Extract and compare pairs that agree on date of birth and gender
Block 7 Using Link Plus: Extract and compare pairs that agree on forename initials, surname initials, and gender
Block 8 Using Stata: Extract and compare pairs that agree on concatenation of forename initials, surname initials, gender, day of birth, month of birth and year of birth
Block 9 Using Stata: Extract and compare pairs that agree on concatenation of surname initials, gender, day of birth, month of birth and year of birth
Block 10 Using Stata: Extract and compare pairs that agree on concatenation of forename initials, gender, day of birth, month of birth and year of birth
Block 11 Using Stata Extract and compare pairs that agree on concatenation of forename initials, surname initials, day of birth, month of birth and year of birth
Block 12 Using Stata: Extract and compare pairs that agree on concatenation of forename initials, surname initials, gender, month of birth and year of birth
Block 13: Using Stata: Extract and compare pairs that agree on concatenation of forename initials, surname initials, gender, day of birth and year of birth
Block 14: Using Stata Extract and compare pairs that agree on concatenation of forename initials, surname initials, gender, day of birth and month of birth
Total number of comparison pairs: 15,350

Comparison specification

The exact comparison function was used to compare each of the seven linkage fields. In this linkage study there were seven matching fields – so the comparison vector could have any one of 128 agreement patterns: [0,0,0,0,0,0,0], [0,0,0,0,0,0,1], [0,0,0,0,0,1,0], … , [1,1,1,1,1,0,1], [1,1,1,1,1,1,0], [1,1,1,1,1,1,1].

As string variables are prone to typographical errors, generally string comparison functions and not the exact comparison function are used. However, as the forename and surname fields in the self-harm file were only available as encoded numerical values, it was not possible to judge the similarity between values and therefore string comparator functions could not be applied. However, the impact of typographical errors in the forename and surnames matching fields may be negligible, as only the first two letters of the strings are being compared and research has shown that typographical errors are less likely to occur at the start of a string.[73]

In order to maximise the possibility of finding matches, the exact comparison function was made less restrictive when comparing the other matching fields, county of residence, forename, surname and year of birth.

The self-harm Registry has been collecting data on every hospital presentation due to self-harm across the country since 2006; therefore if a self-harm patient had any previous self-harm episodes it was possible to extract the county code that was recorded each time the patient presented with self-harm and incorporate this data into the linkage process. It was hoped that this would provide additional information on any change of

addresses at county level, which a patient may have had before the start of the study time period thereby improving the ability to identify potential matches. Therefore, it was decided that agreement on county of residence was satisfied if the county indicated in the mortality data agreed with the county of residence associated with the self-harm patient at the time of any of their presentations to hospital since 2006.

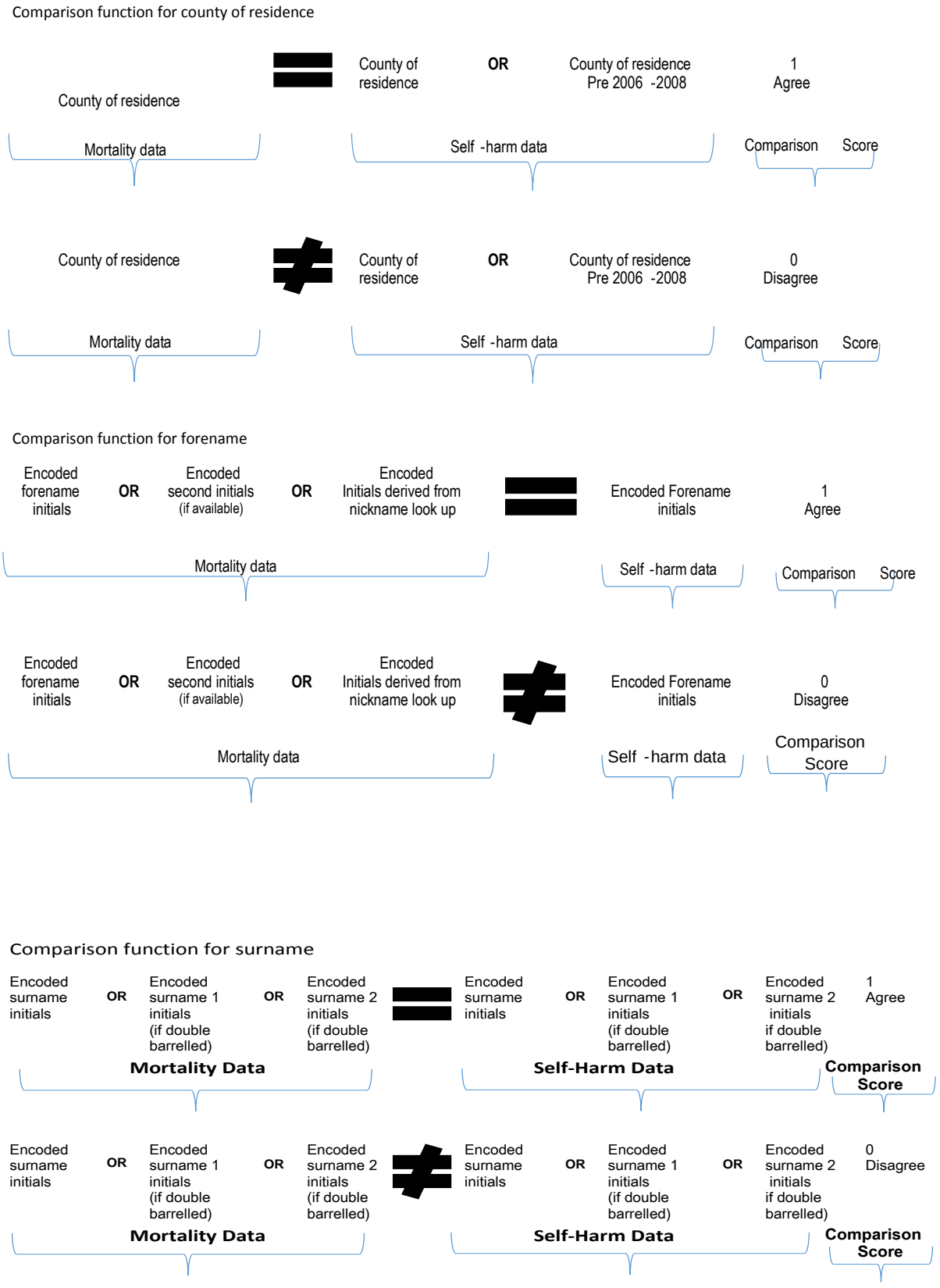
For double-barrelled forenames and surnames, agreement was satisfied if the code from the selected letters matched on either the first or second forename/surname or if there was agreement after replacing forename with a nickname or diminutive version of the forename.

In cases in the mortality file with age but without full date of birth, agreement on year of birth was satisfied if the value in the mortality record was within one year of the value for the corresponding record in the self-harm data.

For the other remaining matching fields; day of birth, month of birth and gender, no adjustments were made therefore the fields had to be exactly the same in order to agree.

Figure 3.2 provides an explanation of the comparison function used for the matching variables: county of residence, forename and surname

Figure 3.2 Comparison function for county of residence, forename and surname matching variables



Validation/Clerical Review of a subset of comparison records

Up to this stage of the record linkage process, agreement patterns have been derived from the matching variables for all comparison pairs selected by the blocking scheme. Some agreement patterns may be always or nearly always associated with correctly matched comparison pairs and other agreement patterns may be never or rarely associated with correctly matched comparison pairs. Distinguishing between such agreement patterns requires obtaining information from additional sources in order to establish the true match status of comparison pairs with as much certainty as possible. If it were possible to obtain and review such additional information for all possible comparison pairs then the record linkage process would be redundant. However, in general it is only feasible to access and review such information for a subset of cases. This subset should be large enough to contain a number of instances of a wide variety of agreement patterns. Otherwise it will be difficult to distinguish agreement patterns associated with correct matches from those associated with incorrect matches

For this record linkage, clerical review was carried out for 1,252 self-harm records. Some of these records were involved in one comparison pair and some were involved in more than one comparison pair. In total, these 1,252 records were involved in 2,212 (8.2%) of the 15,350 comparison pairs produced by the multiple blocking scheme. A wide range of the 128 possible agreement patterns were represented i.e. agreement on all matching fields, agreement on all matching fields except day of birth, agreement on matching fields except surname code and month of birth etc.

Details of the selected self-harm records were listed by hospital and provided to the NRDSH data registration officers (DROs) who had registered the original self-harm presentations made to their respective hospitals. The DROs retrieved from records the full name, date of birth and address of the self-harm patients. Comparison of these details and verification of the matches with the mortality data was carried out by IBOF, after which the retrieved patient details were erased. Out of the 2,212 comparison pairs that were clerically reviewed, 228 were found to be true matches.

Match weight calculation

The match weight is calculated by getting the logarithm to the base two of a ratio between two probabilities, the M-probability and the U-probability (log2(m/u)). For this data linkage study the U-probabilities were approximated by the probability of chance agreement of the identifier variables and the M-probabilities were derived using a subset of the data that was clerically reviewed,(i.e. where the true match status of record pairs could be established).

Calculating U-probability

U-probabilities are typically derived from the distinct values of the identifiers in larger file in record linkage study, in this case the self-harm Registry file. The self-harm Registry file provides a bigger and more comprehensive source for accurately estimating the frequency of different values for a specific identifier, compared to the smaller mortality file, thus allowing a more accurate estimate of the probability that a given death record would randomly match to a self-harm record for a given identifier.

There are two types of U-probabilities, global frequency ratios which uses the number of distinct values of an identifier and value-specific ratios which take into account the actual distribution of identifier values. For the identifiers day, month and year of birth, gender and county of residence, global frequency ratios were calculated for the U-probabilities. As month of birth has only 12 values there was a 0.083 (1/12=0.083) probability of chance agreement on month of birth. Day of birth can only have 31 values so there was a 0.032 (1/31=0.032) probability of chance agreement on day of birth. Gender has two possible values, so there was a 0.5 probability of chance agreement on

gender. As there are 26 counties in the Republic of Ireland, there was a 0.038 (1/26=0.038) probability of chance agreement on county of residence. For year of birth, there were 85 distinct values in self-harm Registry file, so there would be a 0.012 (1/85 = 0.012) chance agreement on year of birth.

The global frequency ratios indicate the value of the particular identifiers for providing evidence of true links between records.[88] Because chance agreement on year of birth is far less likely than chance agreement on gender, it follows that agreement on year of birth is more persuasive evidence of a true link between records (85:1) than agreement on gender (2:1).

Value specific U-probabilities for the forename and surname matching variables were calculated based on the observed distribution of forename and surname codes in the self-harm Registry file. Value-specific ratios yield a higher match weight for agreement on rare forenames and surnames than agreement on more common forenames and surnames. For example, in a file containing 10,000 records, a commonly occurring Irish surname such a 'Murphy' may appear in 100 records, so the probability of chance agreement on 'Murphy' would be 0.01 (100/10,000 = 0.01). A more uncommon surname, such as a non-Irish surname like 'Zhang' might only appear once in the file, so there would be a 0.0001 (1/10,000=0.0001) probability of chance agreement on the surname 'Zhang'. Chance agreement on a surname such as 'Zhang' is far less likely and is therefore assigned a greater match weight than a match on a common surname such as 'Murphy'. The surnames mentioned in this example are for illustrative purposes and do not represent actual persons in the self-harm Registry data.

Table 3.3 U-probabilities used in the record linkage

Identifier	Values for U	Global U-probability frequency ratios **Agreement**	Global U-probability frequency ratios **Disagreement**
Day of Birth	1/12	0.032	0.968
Month of Birth	1/31	0.083	0.917
Year of Birth	1/85	0.012	0.988
Gender	1/2	0.500	0.500
County of Residence	1/26	0.038	0.962
These values for U are based on the range of values in the identifiers taken from the self-harm Registry. U-probabilities for the specific forename and surname initials are not displayed due data confidentiality restrictions			

Calculating M-probability

The M-probability is the probability that the identifiers will agree given the comparison pair is a true match. M-probabilities were derived using a subset of the comparison pairs that was clerically reviewed. In total 2,221 comparison pairs were clerically reviewed and of these 228 comparison pairs were declared to be true matches. From the clerical review it was found that forename initials agreed in 223/228 of true matches, therefore the probability that forename initial agrees given the comparison pair is a true match is 0.978. The probability that the other identifiers agree given the comparison pair is true match are as follows; surname initial M-probability = 0.956, day of birth M-probability = 0.894, month of birth M-probability = 0.961, year of birth M-probability = 0.982, gender M-probability = 0.996, county of residence M-probability = 0.974. All of M-probabilities are presented in Table 3.4.

Table 3.4 M-probabilities used in the record linkage

Identifier	M-probability frequency ratios **Agreement**		M-probability frequency ratios **Disagreement**	
	Values for M	M-probability	Values for M	M-probability
Forename initials	223/228	0.978	5/228	0.022
Surname initials	218/228	0.956	10/228	0.044
Day of Birth*	185/207	0.894	22/207	0.106
Month of Birth*	199/207	0.961	8/207	0.039
Year of Birth	224/228	0.982	4/228	0.018
Gender	227/228	0.996	1/228	0.004
County of Residence	222/228	0.974	6/228	0.026
These values for M were taken from a subset of clerically reviewed comparison pairs that were declared to be true matches (n=228). ** For the identifiers day of birth and month of birth the denominator is 207 because for 21 of the true matches day and month of birth was missing in mortality dataset, therefore the number of agreements/disagreements could only be reported for 207 of the true matches.*				

Identifiers that agree across two records contribute positively to the weight and identifiers that disagree contribute negatively to the match weight. Each of the weights, w_i corresponds to one of the identifiers (i.e. $_i$ ranges from 1 to the number of identifiers used in the linkage. In this record linkage, each comparison pair would have seven separate weights corresponding to each of seven identifiers (1) forename initials, (2) surname initials, (3) day of birth, (4) month of birth, (5) year of birth, (6) gender and (7) county of residence. The formula used depends on whether the identifiers agree or disagree for a given comparison pair.

$$w_i = \log_2\left(\frac{m}{u}\right) \; if \; identifers \; agree$$

$$w_i = \log_2\left(\frac{1-m}{1-u}\right) \; if \; identifers \; disagree$$

Take gender as an example, in our data the M-probability if gender agrees is 0.996 and the U-probability if gender agrees is 0.5, the M-probability if gender disagrees is 0.004 and the U-probability if gender disagrees is 0.5.

$$w_{gender} = \log_2\left(\frac{0.996}{0.5}\right) = 0.994\ if\ gender\ agrees$$

$$w_{gender} = \log_2\left(\frac{0.004}{0.5}\right) = -6.965\ if\ gender\ disagrees$$

We can see from the formula above that the match weight is 0.994 if gender agrees for a given comparison pair and -6.965 if gender disagrees for a given comparison pair. Values for w_i are calculated for each of seven identifiers and the w_i for each comparison pair are then summed to create w_t. Table 3.5 displays the match weights for the matching variables.

$$w_t = \sum_{i=1}^{k} w_i$$

Where k is the number of identifiers used in the linkage.

In this study we did not apply a penalty for an identifier whose value is missing for example the day and month of birth was missing for 18% of mortality records. Instead the identifier gives no weight value as no decision concerning agreement or disagreement can be made. This is an approach that has been used in other studies.[73]

Table 3.5 Probabilistic match weights used in the record linkage

Identifier	Match Weight **Agreement**	Match Weight **Diagreement**
Day of Birth	4.804131	-3.19094
Month of Birth	3.533353	-4.55538
Year of Birth	6.354617	-5.77844
Gender	0.994218	-6.96578
County of Residence	4.679851	-5.20945
Match weights for the specific forename and surname initials not displayed due data confidentiality restrictions		

Best Link Principle - Removal of non-uniquely matched record pairs

In record linkage it is preferred that only one record in File A (the self-harm Regsitry file) links at most with one record in File B (the mortality file). This type of restriction is appropriate for this record linkage, as ultimately each record can only be involved in one i.e. one self-harm record can only be matched to one death record. However, when dealing with real life data any record could potentially link with one or more different records in subsequent blocking passes.[82]

As mentioned previously, the blocking scheme adopted allowed for each self-harm record to match to multiple mortality records and vice versa. As a consequence, the 15,350 comparison pairs included multiple appearances of some self-harm records and of some mortality records. Therefore, the next step was to discard non-uniquely matched record pairs by keeping only the "best links". For each record that appeared in multiple comparison pairs, the "best link" was defined as the comparison pair with the highest combined weight.[91] This meant that each self-harm record was allowed to link only to the mortality record with which it achieved the highest match weight,

remaining lower scoring non-unique matched pairs were then discarded. The assumption behind this is that a high degree of similarity is expected between records that belong to the same individual which is the fundamental assumption of the record linkage theory. This best link principle has been widely used in many record linkage studies particularly in the linkage of census.[87] After the removal of non-unique record pairs, a total of 4,875 unique record pairs or best link record pairs remained.

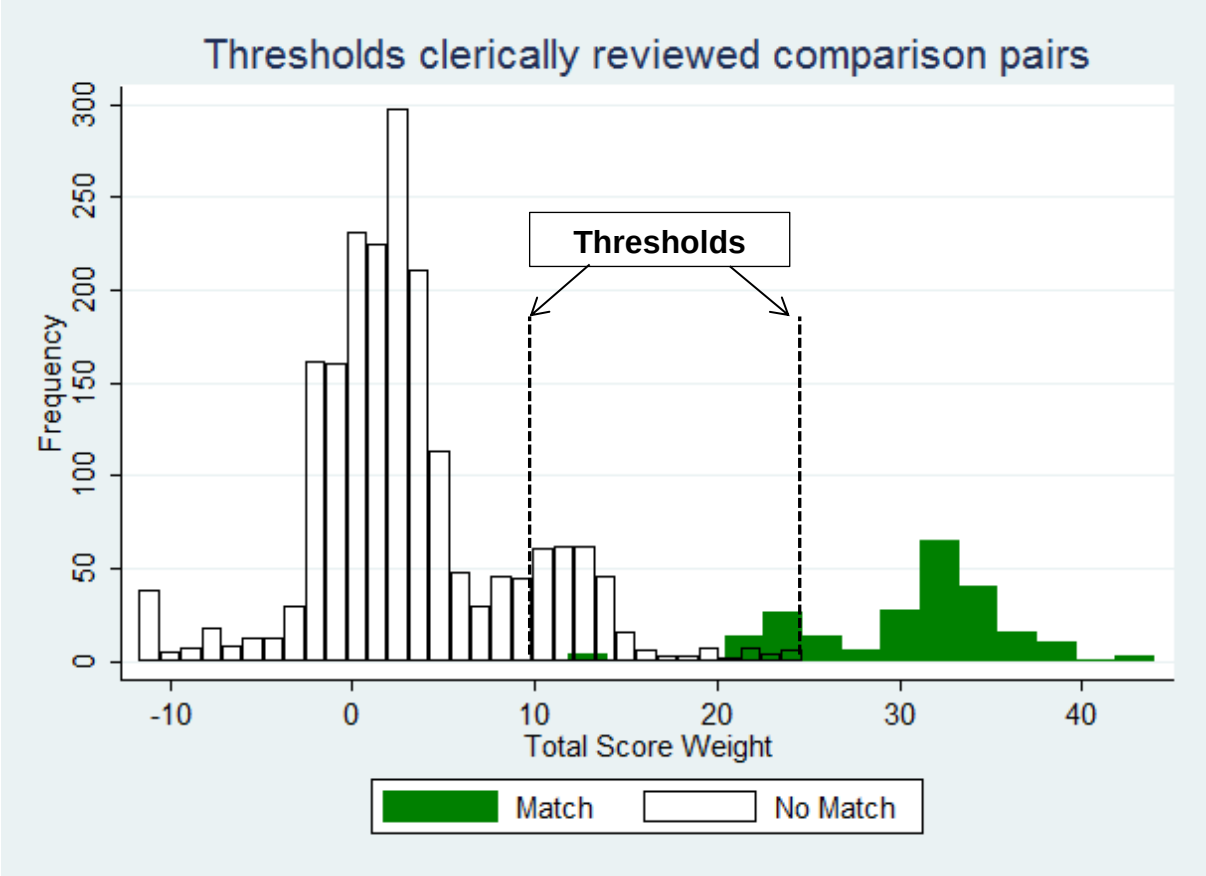
Setting cut-off threshold and classification of comparison pairs as matches or non-matches

The setting of the cut-off above which comparison pairs were declared matches was based on the findings from the clerical review and validation of the subset of 1,252 self-harm records and their associated 2,212 comparison pairs. Applying the best link principle reduced the number of comparison pairs to 916 best link clerically reviewed pairs. These were ranked by their associated match weight so the lower cut off point (point below which pairs are considered non-matches) and upper cut of point (point above which pairs are considered true matches) could be established. Between these upper and lower cut offs lie the comparison pairs that are a mixture of true and false matches.

Out of the 916 comparison pairs that were clerically reviewed, 228 were found to be true matches and 688 were found to be true non-matches. The distributions of match weights for the matches and non-matches are displayed Figure 3.4. The distributions of the matches and non-matches overlap between the points designated as the upper and lower thresholds. From the graph we can see that comparison pairs with a match weight of 24

and above are all true matches, so the match weight 24 was designated as the upper threshold. Below the score of 24 there is mixture of false and true matches. No true matches were found with a match weight below 10, so this was designated the lower threshold.

Figure 3.3: The distributions of match weights for the matches and non-matches for the clerically reviewed comparison pairs



In Table 3.6, the match status of the clerically reviewed and validated comparison pairs and their corresponding match weights are shown. The precision or positive predictive value (PPV) is also displayed. The PPV is the proportion of comparison pairs that are true matches. The precision dropped below 100% among comparison pairs with a score below 24 and was 0% for all comparison pairs with scores less than 10. These cut-off points were applied to the remaining comparison pairs that were not clerically reviewed–

meaning that comparison pairs with scores between 24 and 10 were individually examined to establish their true match status. Comparison pairs with match weights in and around the upper and lower cut off points were also examined.

Table 3.6 Comparison pairs that were clerically reviewed

Score	Not A Match	True Match	Total No. of Comparison Pairs Clerical Review	Precision %
≥42	0	2	2	100
40.0-41.99	0	2	2	100
38.0-39.99	0	6	6	100
36.0-37.99	0	14	14	100
34.0-35.99	0	30	30	100
32.0-33.99	0	52	52	100
30.0-31.99	0	46	46	100
28.0-29.99	0	13	13	100
26.0-27.99	0	9	9	100
24.0-25.99	0	19	19	100
22.0-23.99	6	21	27	78
20.0-21.99	7	9	16	56
18.0-19.99	6	0	6	0
16.0-17.99	9	1	10	10
14.0-15.99	21	0	21	0
12.0-13.99	84	3	87	3
10.0-11.99	74	1	75	1
8.0-9.99	44	0	44	0
6.0-7.99	36	0	36	0
4.0-5.99	87	0	87	0
2.0-3.99	174	0	174	0
0.1-1.99	92	0	92	0
≤0	48	0	48	0
Total	688	228	916	

Decision rules for comparison pairs that were not clerically reviewed

The following decision rules were applied to the 3,959 comparison pairs that were not clerically reviewed in order to declare a comparison pair as being a match or non-match. See Figure 3.4 for a flow diagram describing the complete linkage process.

- All comparison pairs were examined to establish if they had a logical temporal sequence. Any comparison pairs where the date of death preceded the date of self-harm hospital presentation (up to three days discrepant) were discarded.
- Any comparison pair that contained a self-harm record pertaining to a self-harm patient that was found to be active in the 2012-2014 time period were discarded as none of these could be potential matches as these self-harm patients were found to be alive in the years post 2011.
- From the clerical review it was found that comparison pairs that agreed on all of the following matching variables; forename initials, surname initials, gender, day of birth, month of birth and were found to be true matches. Therefore, any of remaining comparison pairs that agreed on all of these matching fields were automatically declared matches, in total 124 comparison pairs were declared as matches.
- As outlined in earlier sections, the self-harm patient's area of residence was coded to an administrative area, known as a district electoral division (DED). To allow for comparison between the two files, the associated address information recorded for each mortality record was also geocoded to a DED area. The DED area variable was not used as a matching variable as it was decided that county of

residence would be a more stable matching variable to use, as any errors in geocoding of address data would most likely result in the incorrect DED being assigned rather than the incorrect county of residence being assigned. Furthermore, a change in residential location would most likely result in a change at the DED level rather than at the county level. However, as DED areas are a finer scale geographical area than county (i.e. there are 3,409 DEDs versus 26 counties in the Republic of Ireland) they have a greater discriminative power to identify an individual compared to county of residence. Thus, DED area would have excellent potential for confirming questionable comparison pairs. To this end, if a comparison pair did not agree on DED area, this did not imply that this comparison pair was not a potential match, however, if a comparison pair had a high match score and agreed on DED area, this provided greater evidence to suggest that the comparison was a match. Likewise, if a comparison pair had a low match score and did not agree on DED, this would provide greater evidence to suggest that the comparison pair was not a match. In an attempt to minimise the effects of any potential changes in address for records in the mortality and self-harm files, the following steps were carried out.

i. As the self-harm Registry has been collecting data on every hospital presentation due to self-harm across the country since 2006; it was possible to extract the DED recorded for previous self-harm presentations made from 2006 onwards. It was hoped that this would provide additional information on any

change of address at DED level, which a patient may have had before the start of the study time period thereby improving the ability to identify potential matches.

ii. Most residential address moves/changes are of a local nature within a county.[92] Therefore, it was important to consider the surrounding areas, i.e. neighbouring DEDs. Neighbouring areas where defined as DEDs that shared a border, i.e first order adjacency. Neighbouring areas were identified by the use of an adjacency matrix using the GIS software, GeoDa.

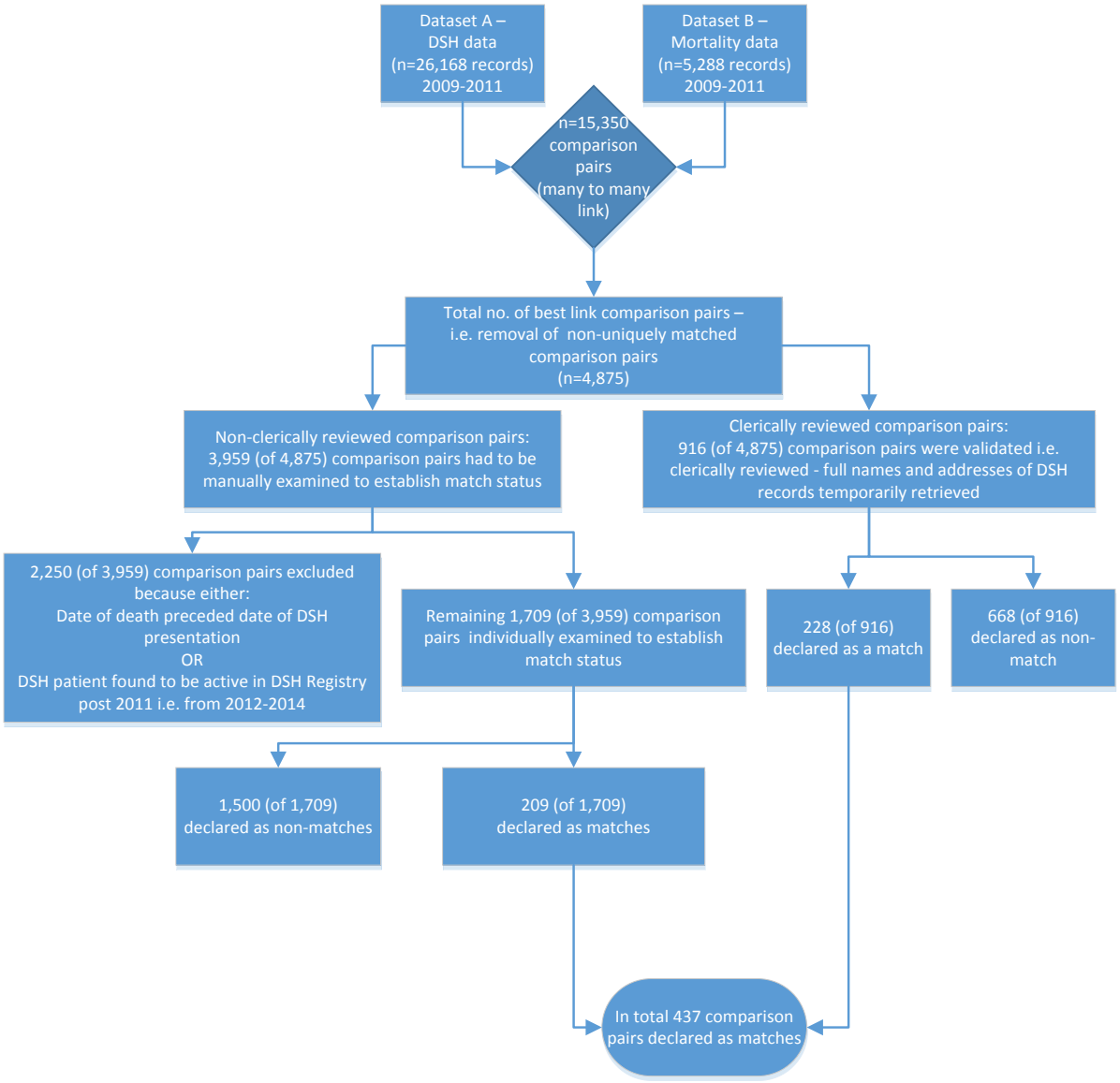
iii. The self-harm Registry and mortality data-files contained a number of other geography-related variables recorded at the geographic aggregation level of county, which could provide additional information reflecting an individual's residential history. For example, the county of the hospital where the self-harm patient attended was taken into consideration. Self-harm patients typically present to the hospital within the county they normally reside in, but a small number of individuals may present to a hospital in a different county - this may reflect short term mobility. Furthermore, the mortality data contained information regarding the county where the death occurred - the county where the death took place may not always be the same as the county in which the deceased individual was recorded as normally residing in, and this information could provide further insight into the residential history for an individual.

- The typical transcription errors in date of birth consist of day and month being transposed, or when two digits for year of birth are transposed. Therefore, all comparison pairs were checked for potential day and month transposition and year of birth transposition errors. General recording errors can lead to the date of birth being a few days different, or one month different or one year different. It was decided that in order for a comparison pair to be declared a match no more than one component of the date of birth could disagree, i.e. either, day or month or year.
- The online death notice resource, RIP.ie was consulted in order to obtain any additional or supplementary identifying information on a deceased individual that may not have been recorded by the CSO. A death notice on RIP.ie contains the name, address and date of death details for a deceased individual, in addition to details of the funeral or memorial service, where donations can be made. All death notices placed on RIP.ie are archived on the site and can be found by searching: surname, county, town or date range. A death notice on RIP.ie may often contain valuable identifying information that may not be recorded in the official mortality data such as nicknames and maiden names, moreover, RIP.ie may contain more detailed address information and also the details of any former addresses that a deceased individual may have had. For example, if a comparison pair did not agree on either forename or surname initials, it was considered a non-match. However, in these instances, death notices

on RIP.ie was checked for any possible nicknames or additional forenames or maiden names.

- In total, of the 3,959 comparison pairs that were individually examined to establish their true match status, 209 of comparison pairs were declared to as matches. Additionally, a total of 228 comparison pairs were declared to be matches from the clerical review process. Therefore, 437 comparison pairs were found to be true matches, i.e. it was found that 437 DSH patients had died due to external causes from 2009-2011.

Figure 3.4 Flow diagram of the overall breakdown of the linkage results



Discussion

The linkage of routine data is an invaluable resource in health research. Record linkage offers a relatively quick, cheap and effective alternative to conducting large scale longitudinal cohort studies and clinical trials, which are expensive and labour intensive to conduct. In other words, record linkage offers the opportunity to create powerful linked datasets consisting of an assembled set of longitudinal records pertaining to an individual, upon which studies that might otherwise have been too expensive or unfeasible to be carried out. Nevertheless, record linkage is not without its limitations. It is rare for databases that contain information about individuals to share a common unique identifier. Therefore, the record linkage of datasets is usually conducted using quasi or partial identifiers such as name, date of birth and address information. Such variables are often prone to reporting, transcription and data entry errors which can affect the quality and accuracy of the record linkage. However, the application of probabilistic data linkage algorithms (as used in this study) provides several solutions for the difficulties caused by errors within personal identifiers.

The major challenge in record linkage is to correctly link records that belong to the same individual from different data sources. In any record linkage study, two types of misclassification errors can occur. Type one error (false negatives) arise due to inconsistent reporting (or non-reporting) of linkage variables across different datasets, resulting in records that should have been matched together not being matched together. Type two error (false positives) is caused by different individuals either rightly or wrongly having common identifiers, resulting in the records for different people being wrongly

matched together. In this record linkage study, type two error is potentially more serious, therefore in order to minimise the number of false positive matches, matching was performed in a conservative manner (as best practice suggests) with regard to the links that should be accepted, so unless other information for matching a pair was available, the records were left as non-matches. Additionally, the logical checks carried out during the linkage stage should have identified or at least minimised these erroneous matches. However, minimising the number of false positives may increase the number of false negatives or missed matches. In this study, failure to link may lead to a lower estimate of the actual risk of death after self-harm, but does not introduce bias in the study's effect measure. We believe our risk estimates may be on the lower bounds for the true risk estimate because the data linkage may not have captured all patients who died in the given period, particularly those who died outside of Ireland. In Ireland, the absence of this unique health identifier (UHI) for individuals is the single most important deficiency in the health information infrastructure.

Chapter 4

Hospital treated deliberate self-harm and risk of suicide and death from other external causes in the Republic of Ireland – a national registry cohort study

This study has been written up in the format to allow for submission to a peer reviewed academic journal. Submission to a high impact journal is underway.

Abstract

Background

Suicide is a major public health problem. The prediction of suicide is difficult, however research has identified that self-harm is the strongest predictor for future suicide. To date, the risk of suicide in individuals who self-harm is not well established internationally as relatively few countries have accurate data on self-harm. Ireland was one of the first countries in the world to set up a standalone national Registry specifically dedicated to the population monitoring of hospital treated deliberate self-harm. Despite this, the risk of suicide among hospital treated self-harm patients is yet to be established in Ireland. Numerous studies have reported regional and sub-national estimates on risk of premature death after deliberate self-harm, but there is a paucity of studies reporting national estimates. This is the first registry based study to examine the risk of mortality on a national cohort of all individuals presenting to hospital due to self-harm in Ireland.

Methods

A national prospective cohort of 26,168 self-harm patients attending the 40 hospital emergency departments in the Republic of Ireland from 2009 to 2011, were followed up until to the end of 2011 using national death recording systems. Gender specific age adjusted European standardised rates for external cause mortality were calculated. Additionally, Poisson regression was used to generate incidence rate ratios for external cause mortality in the self-harm population compared to the general population. Potential risk factors were investigated using Cox Models.

Findings

During the study follow-up 437 patients died from external causes. The 1-year cumulative incidence for suicide, non-suicide external cause mortality and all external causes combined were 0.8% (95%CI 0.7-1.0), 0.5% (95%CI 0.4-0.6) and 1.3% (95%CI 1.2-1.5), respectively. The risk of suicide was 46 times (95% CI 39-54) greater in self-harm population compared to the general population with higher relative risks in females (IRR 63 95% CI 46-87) than in males (IRR 43 95% CI 35-51). The risk of non-suicide external cause mortality was also increased in the self-harm population (females: IRR 30.0; 95% CI 21-44; males: IRR 20.0; 95% CI 15-25). While the relative risk of death were higher in the female self-harm population when compared to the female general population, the absolute risk of death (for both suicide and non-suicide external cause mortality) was found to be higher in males than females. Older age and male gender were associated with an elevated risk of death. Risk of death from suicide (not non-suicide external causes) varied depending on method of self-harm. Compared with overdose alone attempted hanging had the greatest risk of suicide, particularly in females (females; HR 6.8 95% CI 3-15.7, males; HR 2.6 95% CI 1.6-4.3), major self-cutting was also associated with a 2-fold increased risk (HR 2.1 95% CI 1.3-3.5). Self-harm repetition was found to be a strong predictor of subsequent death. Compared to individuals with no repeat acts, persons with a history of three or more repeat acts had a 3.7 fold increased risk (HR 3.7, 95% CI 2.5-5.7) of all external cause mortality with this association being most marked in females (females; HR 6.7, 95% CI 3.8-12.0 and males; HR 2.3, 95% CI 1.2-4.4).

Discussion

The findings from the world's first national self-harm registry highlight the extremely high risk of death from suicide and other external causes following hospital treated self-harm. Older age, male gender, individuals with one or more repeat self-harm acts (especially for females) and persons presenting with attempted hanging or major self-cutting are at a particular risk. There is a need for well-structured, specialist and organised care for this vulnerable group attending emergency departments.

Background

Deliberate self-harm is a major global public health problem. In the Republic of Ireland, the incidence of self-harm has been reported as being higher than the European average for both males and females. Despite differences in the incidence of deliberate self-harm, previous research has shown that the pattern of self-harm presentations to Irish hospitals are broadly similar to studies from other countries with the higher rate in women, the peak in early adult life and drug overdose being the most common method of self-harm.[23]

International research has shown that self-harm is the strongest risk factor for suicide. In a 2002 systematic review of 90 studies from Europe, North America and Australasia published after 1970, the cumulative incidence of suicide following presentation to hospital with self-harm was poorly estimated due to study heterogeneity related to the sampling strategy (emergency department versus inpatient samples and first versus repeat presentations), the methods of ascertainment of subsequent suicide and sample size. The incidence of suicide was estimated at between 0.5% to 2.0% in the year following an act of self-harm and above 5% after 9 years of follow-up.[93] In a further systematic review reported in 2014, and based on 170 studies, similar issues were identified.[25] In the latter study the overall 1 year rate of repeat self-harm was estimated as 16.3%, ranging from 13.7% when studies were based on hospital admissions data to 21.9% when data were based on patient report. Fatal repeat self-harm was estimated to occur in 1.6% of people within 1 year after their index attempt and the incidence rate was almost doubled in males compared to females (2.7% vs. 1.2%). Age, gender

and method of self-harm explained a large proportion of the between study variation in estimates of suicide following self-harm.

However, the risk of suicide after self-harm is not well established internationally as relatively few countries have accurate data on self-harm. A number of cohort linkage studies in England [94-96], America[97], Finland[98, 99] and many other countries have examined risk of death after self-harm but were restricted to examining hospital treated self-harm attendances at city or regional level. Studies that have been carried on a national scale (for example in Sweden[46] and Scotland[100]) have only studied self-harm patients that were admitted to a hospital ward. This is a limitation as admission to a ward is often influenced by the type of method used in the self-harm act, with individuals engaging in the more lethal methods being more likely to be admitted than cases using less lethal methods such as self-cutting.

While there is evidence that the type of method used in the self-harm episode can predict subsequent suicide, with more violent methods such as hanging being associated with the greatest risk.[46, 101] Data on this issue are relatively sparse. However, there is emerging evidence that persons using less lethal methods of self-harm such as self-cutting are also at an increased risk of suicide. A study by Cooper et al[94] was the first to establish the association between suicide risk and self-cutting. Furthermore, more recent research has also reaffirmed this finding.[101] However, of the studies that have examined the association between self-cutting and risk of mortality none have distinguished between the medical severity of self-cutting. It is important to investigate the difference in risk of death within this subgroup as other research has shown that the risk of repetition differs depending on the

medical severity of the self-cutting.[102] This study would be the first to investigate the association between risk of death and self-cutting severity. Moreover, the relationship between other potential risk factors has not been investigated as extensively. For example socioeconomic deprivation has been found to be associated with suicidal behaviour but to date only two studies have examined the association between mortality after self-harm and socioeconomic deprivation.[96, 100] Furthermore no study has investigated the association between mortality after self-harm and area type and social fragmentation. There is also evidence from the UK that the risk of accidental poisoning is significantly increased following a hospital presentation with self-harm.[32] Given the potential for misclassification between these and other external causes of death and suicide, there is a need for reliable estimates of the risk of both suicide and other external causes of death following an episode of self-harm.

Using a national cohort of individuals presenting to hospital with self-harm, the aim of this study is to estimate the risk of all external cause mortality (subdivided into suicide and non-suicide external causes) after self-harm. Potential risk factors from the patients' last hospital presentation of self-harm will be investigated.

Methods

Setting and Sample – The National Registry of Deliberate Self-Harm Ireland

Data on deliberate self-harm for the years 2009–2011 were taken from the National Registry of Deliberate Self Harm Ireland (NRDSH). The self-harm Registry is a national surveillance system that records and monitors all the

self-harm presentations made to each 40 hospital emergency department across whole the Republic of Ireland. Further details of the Registry's case ascertainment and case definition are outlined in a study by Perry et al.[23] Data on self-harm presentations are collected by dedicated data registration officers who operate independently of the hospitals and there is standardised application of case definition and inclusion/exclusion criteria. The Registry uses a case definition of deliberate self-harm that has been developed by the former WHO/Multicentre Study on Parasuicide,[89] this definition and has been widely applied in research. For self-harm patients who presented to hospital more than once during the study period, only the most recent episode (the last episode) and the management received during that episode was included.

External Cause Mortality Data

The Irish Central Statistics Office (CSO) provided data relating to all deaths by external cause (codes V01– Y98 of the Tenth Revision of the International Classification of Diseases, Injuries and Causes of Death (ICD-10) that occurred from 2009 to 2011. For the purpose of this study, deaths of undetermined intent (Y10-Y34) were combined with suicide deaths (X60-X84) (as is standard practice in suicide research) and from herewith shall be referred to as suicide deaths.

Data Linkage

To identify mortality among the self-harm patient cohort, the National Registry of Deliberate Self Harm Ireland data was electronically linked to official mortality data from CSO in a process known as data linkage. Data linkage can be defined as the process of bringing together two or more separately recorded pieces of information that belong to a particular individual.[69] Currently, in Ireland there is no unique health identifier, therefore no single unique matching variable exists for undertaking the linkage of different data sources. In the absence of a unique identifier, personal identifiers also called quasi-identifiers can be used. [81] Therefore, the self-harm Registry data and CSO mortality data were linked using a combination of the following personal identifiers (linkage variables); encoded forename initials, encoded surname initials, gender, day of birth, month of birth, year of birth and county of residence. Probabilistic data linkage was the type of linkage methodology technique used. Probabilistic record linkage attempts to link two pieces of information together using multiple non unique personal identifiers. Probabilistic data linkage estimates the probability/likelihood that two records belong to the same person or not. Probabilistic matching was carried out using the traditional Fellegi and Sunter probabilistic techniques.[71]

Statistical Analysis

The risk of all external cause mortality (subdivided into suicide and non-suicide external causes) within 1 year of the last self-harm episode (in persons aged 15 years and above) was compared with the general population rates of all external causes in Ireland. This was done using

Poisson regression (adjusting for age) to generate gender specific age adjusted incidence rate ratios for suicide, non-suicide external cause mortality and all external causes combined. Additionally, European age adjusted mortality rates per 100,000 for the self-harm population and the general population were calculated. Patients from the third year who had a follow up of less than 1 year were excluded in the calculation of the rates and rate ratios. The Kaplan–Meier method was used to plot the survival curves and to estimate survival probability for both suicide and non-suicide external cause mortality. Survival time began from the date of the self-harm presentation and ended at either death or end of the follow-up period. Log rank tests were carried out to investigate if there were age or gender differences in terms of risk of suicide and non-suicide external cause mortality. Separate univariate and multivariate Cox proportional hazard models were used to identify factors associated with risk of suicide, non-suicide external causes and all external causes combined during the total follow up period. The factors were; age, gender, the method used in last episode of self-harm, recommended next care, alcohol use and history of previous self-harm in the year before the last act of self-harm. Furthermore, in the Cox regression analyses, the association between the severity of self-cutting and risk of subsequent mortality was also examined. The severity of self-harm was defined based on type of treatment received. Acts of self-cutting were defined as ‘minor’ if the treatments included no treatment or wound cleaning, steristrips or if the treatment was unknown. Acts of self-cutting were defined as ‘major’ if the treatments included treatment included: sutures and referral to plastics.

Additionally, three ecological risk factors were examined, these included: area level socioeconomic deprivation, social fragmentation and population density. These ecological variables were based on the self-harm patients' area of residence, the district electoral division (DED). DEDs were divided into tertiles based on their HP deprivation score (tertile 1 = least deprived areas, tertile 3 = most deprived areas), their fragmentation score (tertile 1 = least fragmented areas, tertile 3 = most fragmented areas), and area type (tertile 1 = least densely populated areas, tertile 3 = most densely populated areas). The deprivation index used in this study is The Pobal HP Deprivation Index 2011[103] and was based on indicators taken from the 2011 Irish Census. The social fragmentation index was based on Congdon's anomie score[104] and was calculated by summing the z scores for four Census derived variables (% persons who have moved in the last year, % unmarried persons, % single person households and % of persons in private rented accommodation). The classification of an area type was dependent upon the population density of area. Additionally, gender specific Cox regression models were carried out to examine the effect of the various risk factors on suicide and non-suicide external cause mortality. Furthermore, Wald tests were used to determine the effect modification by age and gender for each of the explanatory variables. Results were expressed as hazard ratios with 95% confidence intervals using STATA statistical software version 12.[105]

Results

Characteristics of Study Cohort

From 01 Jan 2009 to 31 December 2011, 26,168 persons presented to hospital due to deliberate self-harm. The cohort consisted of more females than males (females; 52.3%, males; 47.7%), and almost a third of cohort was aged less than 25 years (Table 4.1). The median age for males was 33 years (range 7-89 years) and for females was it was also 33 years (range 7-94 years). In both males and females the most common method of self-harm was overdose (56.9% and 73.6% respectively) followed by minor self-cutting (12.5% and 9.6% respectively). For both genders admission to ward was the most frequent type of care recommended by hospital (males; 46.2%, females; 47.4%). Alcohol was involved in roughly 40% of all self-harm acts (males; 41.9%, females; 38.3%). Almost 16% of individuals had one or more repeat episode(s) of hospital treated self-harm in the year before the last self-act of the study time period.

Deaths

A total of 437 individuals (1.7% of the cohort) died during the period of follow-up, of whom 270 were certified as having died due to suicide (including deaths of undetermined cause) and the remaining 167 from other non-suicide related external causes. The average cumulative incidence of non-suicide external cause mortality within 1 year after the last self-harm episode for males, females and all persons was 0.7% (95% CI 0.6-0.9), 0.3% (95% CI 0.2-0.4) and 0.5% (95% CI 0.4-0.6) respectively. The cumulative incidence of suicide within 1 year after the last self-harm episode (excluding

self-harm patients that presented in 2011 as they had less than a year follow up) for males, females and all persons was 1.3% (95% CI 1.1-1.5), 0.4% (95% CI 0.3-0.6) and 0.8% (95% CI 0.7-1.0) respectively (Table 4.2). The study follow-up time ranged from 1 day to 36 months, with a median follow up of 17 months. The main cause of death is presented in Table 4.3. Hanging was the most common method used in suicide (63.0%), with a much higher proportion males using this method than females (males; 69.6%, females; 46.8%). Overdose was the second most common method used in suicide deaths (16.7%), with a greater proportion of females dying from overdose than males (females; 30.4%, males; 11.0%). Accidental poisoning was the most common cause of non-suicide external cause mortality (76.1%), with little difference between the genders (males; 76.3%, females; 75.5%).

Risk of mortality in the year following the last episode of hospital treated self-harm

The risk of suicide (IRR 46, 95% CI 39-54), non-suicide external cause mortality (IRR 22, 95% CI 18-27) and all external causes combined (IRR 33, 95% CI 29-37) in the first year following self-harm was higher in the self-harm population compared to the general population (Table 4.4). Risks were greater in females than males for all external causes combined (females; IRR 43 95% CI 34-55, males; IRR 30 95% CI 26-35), for suicide (females; IRR 63 95% CI 46-87, males; IRR 43 95% CI 35-51) and also for non-suicide external cause (females; IRR 30 95% CI 21-44, males; IRR 20 95% CI 15-25). However, while the relative risk of death were higher in the female self-harm population when compared to the female general population, the

absolute risk of death (for both suicide and non-suicide external cause) was found to be higher in males than females. In the male self-harm population, the European age adjusted rates for suicide, non-suicide external causes and all external cause combined were 1302 (95% CI 1065-1539), 826 (95% CI 645-1006) and 2127 (95% CI 1830-2425) per 100,000 respectively. In the female self-harm population the European age adjusted rates for suicide, non-suicide external causes and all external cause combined were 649 (95% CI 516-781), 367 (95% CI 254-480) and 1016 (95% CI 842-1190) per 100,000 respectively.

Survival analysis showed that the risk of both suicide and non-suicide external cause mortality was significantly higher for male self-harm subjects than female self-harm subjects (suicide mortality; log rank χ^2=58.48, P<0.001) (non-suicide external cause mortality; log rank χ^2=36.07, P<0.001) Figure 4.1. Additionally, survival analysis also showed that there was a significant difference in risk of suicide and non-suicide external cause mortality between the various age groups (suicide mortality; log rank χ^2=29.58, P<0.01) (non-suicide external cause mortality; log rank χ^2=17.47, P<0.001). For both suicide and non-suicide external cause mortality the youngest age group (<24 years) had the lowest risk. The 45-64 age group had the greatest risk of suicide and the 25-44 age group had the greatest risk of non-suicide external cause mortality.

Cox regression models estimating risk factors for suicide and non-suicide external cause mortality

The association between various demographic, clinical and ecological risk factors related to the last episode of self-harm and subsequent risk of suicide and non-suicide external cause mortality were examined in univariate and multivariate Cox regression models (Table 4.5). The gender specific effect between these covariates and risk of suicide and non-suicide external cause mortality are also examined (Table 4.6).

Risk factors for suicide mortality in all persons

The demographic covariates associated with an increased risk of suicide were male gender (adjusted HR 2.4) and older age with the risk being greatest in 45-64 year age group (adjusted HR 2.5). In terms of clinical risk factors, self-harm patients that used methods of self-harm such as attempted drowning (adjusted HR 2.0) major self-cutting (adjusted HR 2.1) and in particular attempted hanging (adjusted HR 3.3) had an elevated risk of subsequent suicide compared to patients that used overdose alone as a method of self-harm.

Minor self-cutting was not associated with an increased risk of suicide. Additionally, self-poisoning was associated with an elevated risk of suicide (adjusted HR 2.6). Looking at the association between recommended next care and suicide risk, individuals who were admitted to a general ward had the greatest risk (adjusted HR 2.5). Individuals who had a history of one or more repeat acts of hospital treated self-harm in the year before the study commencement had an increased risk of suicide. The use of alcohol in the

last episode of self-harm was found to be associated with a reduced risk of suicide (adjusted HR 0.6). The risk of suicide was most elevated in those who engaged in 3 or more repeat self-harm acts (adjusted HR 3.0). No statistically significant association between suicide socioeconomic deprivation, social fragmentation or population density was found.

Risk factors for non-suicide external cause mortality in all persons

The demographic covariates associated with an increased risk of non-suicide external cause mortality were male gender (adjusted HR 2.5) and increasing age. History of previous hospital treated self-harm was strongly associated with an increased risk of non-suicide external cause mortality. Hazard ratios were as high as 5.3 for self-harm patients that had a history of 2 or more acts of self-harm. Socioeconomic deprivation had a significant association with non-suicide external cause mortality, with those in the most affluent areas having a greater risk than those in the most deprived areas (adjusted HR 0.6).

Risk factors for suicide mortality stratified by gender

The gender specific effect between covariates and suicide risk were examined separately for males and females. There was evidence of an age differential in risk of suicide between the genders ($\chi 2=8.91$, d.f=3 $P<0.05$), with increasing age being associated with a greater risk of suicide in females than males, particularly for females in the 45-64 year age group (adjusted HR 7.1). Overall, no significant interaction between gender and type of self-harm was found ($\chi 2=6.8$, d.f=7 $P>0.05$). However, when examining the effect modification between gender and the individual methods of self-harm, a

significant interaction between attempted hanging as a method of self-harm and suicide risk was found (χ2=4.33, d.f=1 P<0.05), with the risk of suicide being greatest in female self-harm patients that attempted hanging compared to male self-harm patients that attempted hanging (adjusted HR 6.8). For both genders, self-harm patients that were admitted to general ward had the greatest risk of suicide, with no overall effect modification between gender and type of admission being found (χ2=5.30, d.f=4 P>0.05). A history of hospital treated self-harm was associated with an increased risk of suicide in both genders, and there was evidence of effect modification by gender (χ2=4.6, d.f=1 P<0.05) with self-harm repetition being associated with a greater risk in females than males. In both males and females, no significant relationship between suicide risk and any of three area level determinants was found.

Risk factors for non-suicide external cause mortality stratified by gender

The gender specific effect between covariates and risk of non-suicide external cause mortality were examined separately for each gender. For both genders, a history of hospital treated self-harm was associated with an increased risk of non-suicide external cause mortality, with repetition having a stronger association in females than males (χ^2=11.95, d.f=3 P<0.01). Alcohol use was associated with a greater risk of non-suicide external cause mortality in females only. Socioeconomic deprivation was found to have an inverse association with non-suicide external cause mortality in males only, with males in the most affluent areas having a greater risk of non-suicide external cause mortality than males in the most deprived areas.

Discussion

Summary of findings

Our study reinforces findings from previous research showing an elevated risk of both suicide and non-suicide external cause mortality in self-harm patients compared to the general population and that the risk of mortality differs by age and gender.

1 year incidence of suicide and non-suicide external cause mortality compared to previous studies

The cumulative incidence of suicide mortality in the first year following self-harm, (0.8%) is comparable if slightly higher than earlier studies carried out in Oxford, England[95] (0.7%) and Northern England[94] (0.5%) and lower than studies from outside of Europe such as Taiwan[106] (1.6%). To date, the highest incidence have been found in studies carried in Nordic countries, such as Sweden (4.2%)[46] and Finland[99] (3.2%). Our estimate of 0.8% (95% CI 0.65-0.9) is lower than estimates from a recent systematic review[25] that found a 1.4% (95% CI 1.1–1.8) risk of suicide based on studies on emergency department attendances and 1.6% (95% CI 1.3–2.1) risk of suicide based on hospital admission studies. The authors of this systematic review concluded that the differences in estimates of suicide risk between countries may be largely due to the differing characterises of the underlying study populations in terms of age, gender and method of self-harm. Additionally, our finding that hospital treated self-harm patients were at an elevated risk of non- suicide external cause mortality are in accordance with previous research.[27, 106]

Gender and Age

In accordance with the majority of studies in this area, we found a higher risk of mortality in male self-harm cases and older age groups.[25, 27, 46, 93, 95, 106]

Method of self-harm in last episode of self-harm

Previous research has already established that method of self-harm either used in the index episode or last self-harm episode is an important predictor of suicide.[101] However, comparisons of findings from studies which demonstrate an association between specific self-harm methods and elevated suicide risks can be difficult because the use of different self-harm methods as the reference category. For example, some studies may use self-poisonings alone[46, 101](excluding CO/other gases), self-poisonings and self-cutting combined[107], or self-poisonings with medicines only as the comparison group.[106, 108] We found that persons using self-harm methods such as poisoning; major self-cutting; attempted drowning; other methods or hanging have a greater risk of suicide than persons using overdose as a method of self-harm. Our results show that persons using hanging as a method of self-harm have a particularly high risk of suicide (adjusted HR 3.2). Earlier studies have also found this association.[46, 101] Previous research also suggests that individuals who self-poison using gas or other non-ingestible poisons have high suicidal intent scores.[109] In this study we found that individuals who used poisoning alone were 2.6 times more likely to die by suicide than individuals that used overdose alone. There is emerging evidence that persons using less lethal methods of self-harm such as self-cutting are also at an increased risk of suicide. Cooper et al[94] was the first to

establish the association between suicide risk and self-cutting. Our study showed that major self-cutting is associated with 2.1-fold increased risk of suicide and this finding is also in keeping with more recent research,[101, 110] however it must be noted that previous studies did not distinguish between the severity of self-cutting. This finding that self-cutting is associated with an increased risk of suicide is quite important as it provides support to the growing body of research that highlights the necessity for this self-harm group to receive a psychosocial assessment as it has been shown that this group often receive inadequate treatment.[101, 111]

Recommended Next care in last episode of self-harm

Our finding that self-harm cases who were admitted to general ward had double the risk of suicide compared to those who were not admitted is in line with results from previous research.[110] This association is not causal, i.e. hospital management being associated with increased risk of death, but instead this finding may be interpreted as hospital staff appropriately detecting a high-risk group for admission to hospital. Kapur et al referred to this as an example of confounding by indication, meaning that allocation to particular treatments was most likely based on the underlying need.[112]

Alcohol use in last episode of self-harm

We found that alcohol was associated with a reduced risk of suicide (protective factor) and an increased risk of non-suicide external cause mortality in females only. This finding of the differing effect of alcohol use on the risk of suicide and non-suicide external cause mortality has been previously demonstrated by Bergen at al.[27] As alcohol misuse is quite

prevalent in the self-harm population, the reduced effect of alcohol use on suicide risk supports a theory proposed by Skog et al[113] which states that the effect of alcohol on suicide risk is lower when overall alcohol consumption is high. The finding of an association between alcohol and an elevated risk of death from other external causes is not surprising as the involvement of alcohol is very common in accidental deaths in particular. Bergen et al[27] suggested that the disinhibiting effect of alcohol may have resulted in carelessness and increasing the likelihood for accidental mortality.

Repetition in the year before the last episode of self-harm

Almost one third (30.0%, 131/427) of the self-harm cases that died during study follow up had a history of self-harm repetition in the year before the last episode of self-harm. A previous history of repetition was associated with a greater proportion of non-suicide external cause deaths (39.5%, 66/167) than suicide deaths (24.1%, 65/270). This finding is in line with previous research.[94, 108] Furthermore, we found that this association was stronger in females than males, again this has been demonstrated elsewhere.[114] Additionally, we found that repetition was associated with an elevated risk of non-suicide external cause mortality. This result is not in accordance with previous research, for example Bergen et at al[27] found no association between repetition and other external cause mortality. In this study, accidental poisonings represent the majority of the non-suicide external cause deaths (75%).

Ecological factors

Socioeconomic deprivation was the only ecological variable that was found to be significantly associated with non-suicide external cause mortality but not suicide mortality. Our results showed that males from the least deprived areas (affluent areas) had a greater risk of non-suicide external cause mortality compared to males from the most deprived areas. The paucity of studies that have previously examined the relationship between socioeconomic deprivation and mortality following self-harm have shown inconsistent evidence. Similar to our findings, a study in Scotland by Hall et al[100] found that individuals from affluent areas had an elevated risk of death (albeit death from suicide). Conversely, research from England[96], has shown that risk of all-cause mortality (not suicide) after self-harm increased with each quartile of socioeconomic deprivation. The differences in these findings may be hard to interpret, but as Hall et al suggested, the fact that self-harm has been shown to be less common in affluent areas (two previous Irish studies[115, 116] have already found this) then this may mean that individuals who do engage in self-harm from affluent areas may be at a particular risk.

Strengths and Limitations

Numerous studies have reported regional estimates on risk of premature death after self-harm, but very few studies have reported national estimates. Moreover, the few studies that have been carried out at a national level are restricted to study samples of self-harm hospital admissions rather than self-harm hospital attendance populations. To our knowledge, this is the first registry based study to examine the risk of mortality on a national cohort of

all individuals attending hospital due to self-harm. Furthermore, it has been suggested that there are compositional differences between hospital admission based samples and self-harm hospital attendance samples, as the self-harm cases that lead to inpatient hospital admission are often seen as more serious self-harm cases engaging in more lethal methods of self-harm. Moreover, it has been shown that admission rates following self-harm presentation vary greatly between hospitals, which can cause significant bias in such studies.[117] To date, the majority of studies investigating the potential risk factors associated with premature mortality in individuals who self-harm have focused on the details concerning the index episode of self-harm during a given study period. However, it has been suggested that studying an individuals' last act of self-harm can be more relevant to the subsequent death than the first episode of self-harm.[27] In this study we have examined the individual's' last episode of self-harm. Lastly, one of the main strengths of the study is the large sample size (n=26,168), as large sample size is necessary to study such a rare outcome as suicide.

This study has a number of limitations also. Attrition bias may be an issue as it was not possible to trace the self-harm patients who may have emigrated during the study time period. As the self-harm Registry has national coverage of all hospitals, selection bias is generally not an issue, however, it is plausible that the urban location of the majority of hospitals may lead to an over representation of self-harm cases from urban settings. Furthermore, detailed information on the self-harm patient such as data on suicidal intent, psychosocial assessment, psychiatric diagnosis, marital status and socioeconomic status are not collected by the Registry thus limiting our

ability to control for these potential confounders. Lastly, there are a number of issues associated data linkage techniques. In Ireland there is no unique health identifier; therefore linkage can only be done using a combination of non-unique personal identifiers. There is the possibility of failure to link due to errors in the personal identifier i.e. misspelling of the name or misreporting of date of birth, this may result in failed, incorrect or missed matches. However, the application of probabilistic data linkage algorithms (as used in this study) provides several solutions for the difficulties caused by errors within personal identifiers. Failure to link gives a lower estimate of the actual mortality but does not introduce bias in the study's effect measure. We believe our estimates may be lower than expected rates because the data linkage may not have captured all patients who died in the given period, particularly those who died outside of Ireland. In Ireland, the absence of this unique health identifier (UHI) for individuals is the single most important deficiency in the health information infrastructure.

Implications for Intervention/services delivery

The National Clinical Care Programme (NCP) for the Assessment and Management of Patients Presenting to Emergency Departments Following Self-harm was established to address the deficiencies and diversities in the assessment and management of self-harm patients who present to emergency hospital departments across the county.[118] The NCP states that all patients presenting to a hospital emergency department due to self-harm, regardless of suicidal intent, should receive standardised triage, bio-psycho-social assessment and assertive follow up by skilled health professionals. Our research findings fully support these recommendations. The findings of

this study show that risk factors for suicide in the self-harm population, were male gender, older age, previous self-harm and method of self-harm (especially hanging). We also found that male gender, older age, self-harm repetition and the involvement of alcohol were associated with an increased risk of non-suicide external cause mortality. Identification and assessment of future risk of death in self-harm patients is a difficult task as the discriminatory power of risk factors is low. The ability of clinicians to assess the risk of patients killing themselves is important and demanding as it is often a key factor that informs clinical decisions, such as deciding which treatments are selected and whether admission to a psychiatric ward is necessary. However, a greater understanding of the demographic characteristics and clinical factors associated with risk of mortality after hospital treated self-harm may help inform clinical practice.

Method of self-harm and risk of subsequent suicide

For example, we demonstrated that attempted hanging was associated with a particularly high risk of suicide. This is an important finding for emergency department staff who treat self-harm patients. It is imperative that all individuals who self-harm regardless of the severity of self-harm and type of self-harm should receive a psychosocial assessment. However, the method of self-harm may help emergency department staff identify the self-harm patients at a particularly high risk of suicide to ensure that they receive adequate treatment and intensive follow up. Moreover, our finding that major self-cutting was associated with an increased risk of suicide is an important finding as research has shown that this group of self-harm patients often receive inadequate treatment. Furthermore, to prevent a subsequent episode

of self-harm using the same method, a patient's access to means should be investigated by emergency department staff and where possible access to means should be restricted.

Involvement of alcohol at the time of self-harm and risk of subsequent suicide

Alcohol misuse is widespread among all individuals who self-harm, in Ireland alcohol is involved in nearly 40%[119] of hospital treated self-harm episodes and half of people who die by suicide have had a history of alcohol abuse in the final year of their lives.[120] The NCP states there is an 'urgent need' for the implementation of the recommendations of the National Substance Misuse Strategy to tackle alcohol abuse in individuals who self-harm. The findings from this study also highlight the importance of tackling alcohol misuse in the self-harm population. We found that in females, alcohol consumption during the last episode of hospital treated self-harm was associated with an increased risk of non-suicide external cause mortality, mainly deaths due to accidental poisonings. Research in the UK has demonstrated that addressing alcohol misuse was an important step to recovery in people who self-harm.[121] The NCP recommends that the assessment of potential alcohol misuse should be incorporated into the bio-psycho-social assessment of all self-harm patients. Furthermore, all staff carrying out a mental health assessment should be trained to carry out screenings for alcohol problems and each emergency department should have clear policies for referral to relevant local Addiction Services.

Self-Harm Repetition and risk of suicide

The NCP recommends that a specific focus is required for the subgroup of self-harm patients who engage in self-harm repetition and that improved assessment and management of self-harm is likely to reduce the risk of repeated self-harm and hence reduce the risk of suicide. Our finding that self-harm repetition was a strong predictor of both suicide and non-suicide external cause mortality supports the NCP recommendation for improved assessment and management of this vulnerable sub group.

Acknowledgments

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Table 4.1 Cohort Characteristics - Self-Harm Patients Presenting to Hospital, 2009-2011

	Males N. %	**Females N. %**	**Persons N. %**
Gender	12479 (47.7)	13689 (52.3%)	26168 (100%)
Age in years			
>25	4046 (32.4)	4765 (34.8)	8811 (33.67)
25-45	5935 (47.6)	5656 (41.3)	11591 (44.29)
45-64.99	2199 (17.6)	2904 (21.2)	5103 (19.5)
65+	299 (2.4)	364 (2.7)	663 (2.53)
Method Self-Harm			
Overdose only [a]	7103 (56.9)	10079 (73.6)	17182 (65.7)
Poisoning only [b]	143 (1.2)	106 (0.8)	249 (1.0)
Minor Cutting only [c]	1556 (12.5)	1311 (9.6)	2867 (11)
Major Cutting only [d]	754 (6.0)	429 (3.1)	1183 (4.5)
Overdose & cutting	524 (4.2)	530 (3.9)	1054 (4)
Attempted hanging only	786 (6.3)	273 (2)	1059 (4.1)
Attempted drowning only	359 (2.9)	228 (1.7)	587 (2.2)
All Other Methods	1254 (10.1)	733 (5.4)	1987 (7.6)
Recommended Next care			
Not admitted	5767 (46.2)	6488 (47.4)	12255 (46.8)
Admission ward	3549 (28.4)	4366 (31.9)	7915 (30.3)
Admission psychiatry	1244 (10)	1086 (7.9)	2330 (8.9)
Patient refused to be admitted	121 (1)	117 (0.9)	238 (0.9)
Left without being seen / without decision	1798 (14.4)	1632 (11.9)	3430 (13.1)
Involvement of alcohol			
No alcohol involved	7253 (58.1)	8449 (61.7)	15702 (60)
Alcohol involved	5226 (41.9)	5240 (38.3)	10466 (40)
Repetition [e]			
No repeat act	10453 (83.8)	11496 (84)	21949 (83.9)
1 repeat act	1336 (10.7)	1444 (10.6)	2780 (10.6)
2 repeat act	399 (3.2)	417 (3.1)	816 (3.1)
3 or more repeat act	291 (2.3)	332 (2.4)	623 (2.4)

[a] ICD-10-codes X60-X64

[b] ICD-10-codes X66-X69

[c] Minor self-cutting defined based on type of treatment received – treatments included no treatment or wound cleaning, steristrips and treatment unknown

[d] Major self-cutting defined based on type of treatment received –treatment included: sutures and referral to plastics

[e] Repetition was defined as the number of repeat acts in the year before the last episode of self-harm

Table 4.2 Cumulative incidence of suicide within 1 year after self-harm act

	All External Cause Mortality % (95% CI)	Suicide Mortality % (95% CI)	Non-Suicide External Cause Mortality % (95% CI)
Males	2.0 (1.7-2.3)	1.3 (1.1-1.5)	0.7 (0.6-0.9)
Females	0.7 (0.6-0.9)	0.4 (0.3-0.6)	0.3 (0.2-0.4)
All Persons	1.3 (1.2-1.5)	0.8 (0.7-1)	0.5 (0.4-0.6)
Self-harm cases that presented in 2011 were excluded as they did not have a follow up period of at least 1 year			

Table 4.3 Causes of Death in Study Cohort, 2009-2011

Method of Death	Males No. %	Females No. %	Total No. %
Suicide Mortality			
Overdose	21 (11)	24 (30.4)	45 (16.7)
Poisoning	6 (3.1)	0 (0)	6 (2.2)
Hanging	133 (69.6)	37 (46.8)	170 (63)
Drowning	16 (8.4)	12 (15.2)	28 (10.4)
Other	15 (7.9)	6 (7.6)	21 (7.8)
Total	**191**	**79**	**270**
Non-Suicide External Cause Mortality			
Accidental Poisonings	90 (76.3)	37 (75.5)	127 (76.1)
Road Traffic Accidents	8 (6.8)	1 (2)	9 (5.4)
Falls Accidental	7 (5.9)	6 (12.2)	13 (7.8)
Other	13 (11)	5 (10.2)	18 (10.8)
Total	**118**	**49**	**167**

Table 4.4 Age adjusted European standardised rates and incidence rate ratios for external cause mortality in the self-harm population and general population, Republic of Ireland 2009-2010

	Persons Rate 95% CI	**Males Rate 95% CI**	**Females Rate 95% CI**
General Population Age Adjusted rate[1]			
All External Cause Deaths	47 (46-49)	71 (69-73)	24 (23-26)
Suicide and Undetermined Deaths	17 (17-18)	28 (27-29)	7 (6-8)
Non-Suicide External Cause Deaths	30 (29-31)	43 (41-45)	17 (16-19)
Self-Harm Population Age Adjusted rate[1]			
All External Cause Deaths	1531 (1362-1700)	2127 (1830-2425)	1016 (842-1190)
Suicide and Undetermined Deaths	949 (816-1082)	1302 (1065-1539)	649 (516-781)
Non-Suicide External Cause Deaths	582 (478-687)	826 (645-1006)	367 (254-480)
Incidence Rate Ratio[2]			
All External Cause Deaths	33 (29-37)	30 (26-35)	43 (34-55)
Suicide and Undetermined Deaths	46 (39-54)	43 (35-51)	63 (46-87)
Non-Suicide External Cause Deaths	22 (18-27)	20 (15-25)	30 (21-44)

[1] Age adjusted rate per 100,000 in persons aged 15 years and above- These are European age-standardised rates. Self-harm cases that presented in 2011 were excluded as they did not have a follow up period of at least 1 year.

[2] Rate ratios based on Poisson regression adjusting for age in persons aged 15 years and above. The risk of mortality in self-harm population was compared to the risk of mortality in the general population. Self-harm cases that presented in 2011 were excluded as they did not have a follow up period of at least 1 year

Table 4.5 Cox proportional hazard model

	All External Cause Deaths		Suicide Deaths		Non-Suicide External Cause Deaths	
	IRR[1] 95% CI	IRR[2] 95% CI	IRR[1] 95% CI	IRR[2] 95% CI	IRR[1] 95% CI	IRR[2] 95% CI
Age						
15-24	1.00	1.00	1.00	1.00	1.00	1.00
25-44	2.0 (1.6-2.6)	1.9 (1.4-2.4)	1.9 (1.4-2.6)	1.9 (1.4-2.6)	2.2 (1.5-3.3)	1.8 (1.2-2.8)
45-64	2.3 (1.7-3.0)	2.3 (1.7-3.0)	2.5 (1.8-3.6)	2.5 (1.8-3.7)	1.9 (1.2-3.0)	1.8 (1.1-2.9)
65+	2.0 (1.1-3.6)	2.0 (1.1-3.7)	2.5 (1.3-5.0)	2.2 (1.1-4.4)	1.2 (0.4-4.0)	1.6 (0.5-5.2)
Gender						
Females	1.00	1.00	1.00	1.00	1.00	1.00
Males	2.7 (2.2-3.3)	2.5 (2.0-3.1)	2.7 (2.1-3.5)	2.4 (1.9-3.2)	2.7 (1.9-3.7)	2.5 (1.8-3.5)
Self-Harm Method						
Overdose only	1.00	1.00	1.00	1.00	1.00	1.00
Minor Cutting only	1.0 (0.7-1.4)	1.1 (0.7-1.5)	0.7 (0.5-1.2)	0.9 (0.6-1.6)	1.3 (0.8-2.1)	1.2 (0.7-1.9)
Overdose & cutting	1.1 (0.6-1.8)	1.1 (0.7-1.9)	1.2 (0.6-2.2)	1.3 (0.7-2.5)	0.9 (0.4-2.2)	0.9 (0.4-2.1)
Attempted hanging only	2.3 (1.6-3.3)	2.2 (1.5-3.2)	3.5 (2.4-5.2)	3.3 (2.1-5)	0.7 (0.2-1.8)	0.6 (0.2-1.8)
Attempted drowning only	1.6 (0.9-2.8)	1.3 (0.7-2.4)	2.2 (1.1-4.1)	2.0 (1.0-4.0)	0.9 (0.3-2.7)	0.3 (0-2)
All Other Methods	1.8 (1.3-2.4)	1.6 (1.1-2.2)	2.2 (1.5-3.1)	1.8 (1.2-2.7)	1.3 (0.8-2.2)	1.3 (0.7-2.2)
Major Cutting only	1.7 (1.1-2.5)	1.5 (1-2.3)	2.1 (1.3-3.4)	2.1 (1.3-3.5)	1.1 (0.5-2.3)	0.7 (0.3-1.7)
Poisoning only	2.3 (1.1-4.6)	2.0 (1.0-4.2)	3.5 (1.6-7.4)	2.6 (1.2-5.6)	0.7 (0.1-4.7)	0.8 (0.1-5.9)
Recommended Next care						
Not admitted	1.00	1.00	1.00	1.00	1.00	1.00
Admission ward	2 (1.6-2.5)	2.1 (1.6-2.6)	2.5 (1.9-3.3)	2.5 (1.9-3.3)	1.4 (1.0-2.0)	1.5 (1.0-2.2)
Admission psychiatry	1.7 (1.2-2.4)	1.2 (0.9-1.7)	2.0 (1.3-3)	1.3 (0.9-2.1)	1.3 (0.8-2.3)	1.0 (0.6-1.9)
Patient refused to be admitted	1.1 (0.4-3.5)	0.9 (0.3-2.9)	1.3 (0.3-5.3)	1.0 (0.2-4.1)	0.9 (0.1-6.3)	0.8 (0.1-5.8)
Left without being seen	1.6 (1.2-2.1)	1.3 (1-1.8)	1.2 (0.8-1.9)	1.2 (0.8-1.9)	2.1 (1.4-3.1)	1.4 (0.9-2.2)
Involvement of alcohol						
No Alcohol involved	1.00	1.00	1.00	1.00	1.00	1.00

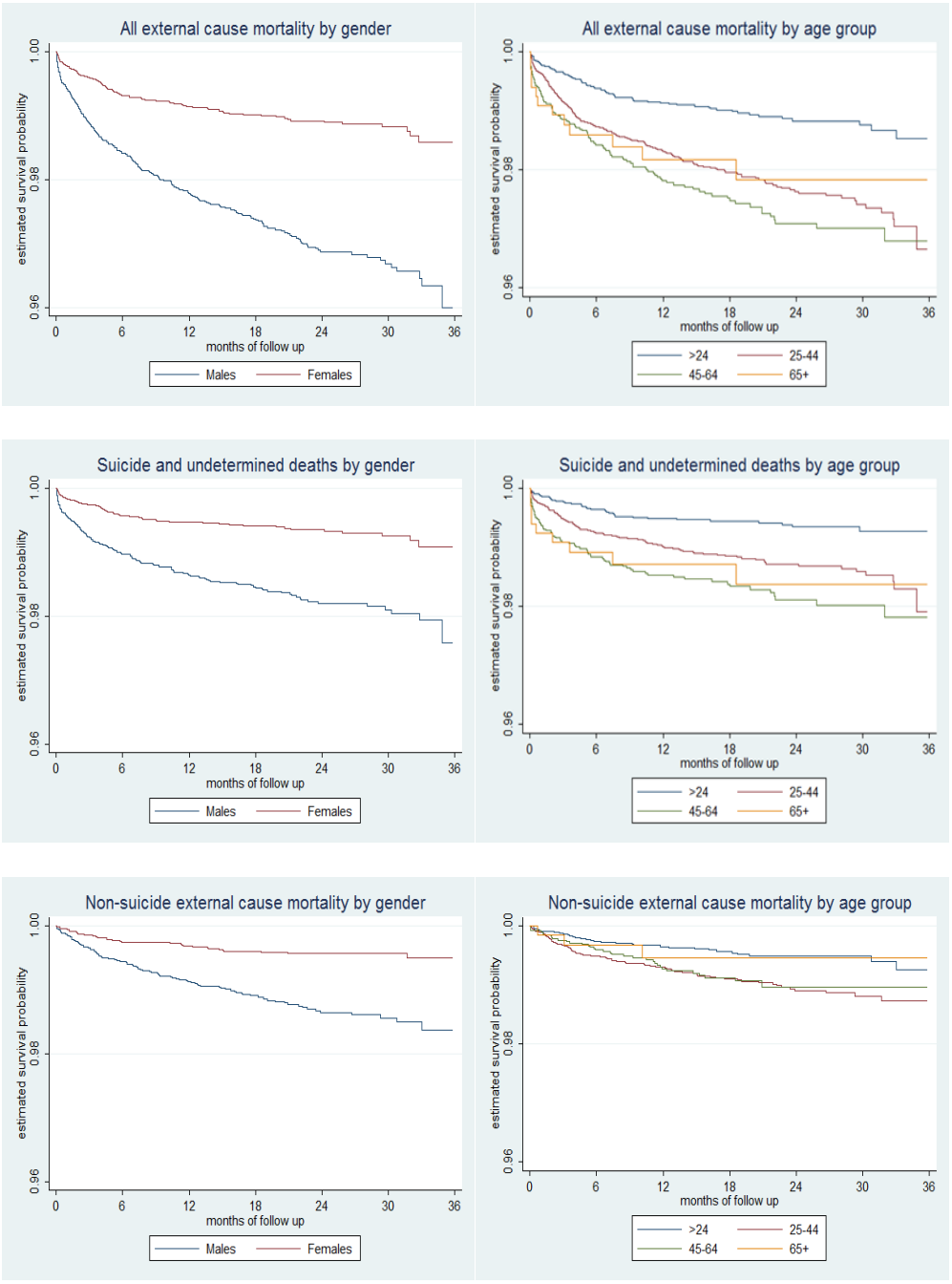
Alcohol involved	1.0 (0.8-1.2)	0.9 (0.7-1.1)	0.7 (0.5-0.9)	0.6 (0.5-0.8)	1.6 (1.2-2.1)	1.4 (1.0-1.9)
Self-Harm Repetition						
No repeat act	1.00	1.00	1.00	1.00	1.00	1.00
1 repeat act	1.8 (1.4-2.4)	1.8 (1.3-2.3)	1.4 (1.0-2.0)	1.2 (0.8-1.8)	2.8 (1.9-4.2)	2.9 (2.0-4.4)
2 repeat act	3.2 (2.3-4.6)	3.4 (2.4-4.9)	2.3 (1.4-3.9)	2.5 (1.5-4.2)	5.2 (3.1-8.6)	5.3 (3.1-8.9)
3 or more repeat act	4.2 (2.9-6.1)	3.7 (2.5-5.7)	3.1 (1.8-5.2)	3.0 (1.7-5.3)	6.7 (3.9-11.4)	5.3 (2.8-10.0)
Socioeconomic Deprivation						
Tertile 1 (least deprived)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	0.8 (0.6-1.0)	0.7 (0.5-0.9)	0.9 (0.7-1.3)	0.9 (0.6-1.2)	0.5 (0.3-0.8)	0.5 (0.3-0.7)
Tertile 3 (most deprived)	0.9 (0.7-1.1)	0.7 (0.6-0.9)	0.9 (0.7-1.3)	0.8 (0.6-1.1)	0.7 (0.5-1)	0.6 (0.4-0.9)
Social Fragmentation						
Tertile 1 (least fragmented)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	1.3 (0.8-2.0)	1.3 (0.8-2.0)	1.2 (0.7-2.1)	1.3 (0.7-2.2)	1.4 (0.5-3.4)	1.3 (0.5-3.3)
Tertile 3 (most fragmented)	1.4 (1-2.2.0)	1.4 (0.9-2.2)	1.2 (0.7-1.9)	1.2 (0.7-2.1)	2.3 (1-5.2.0)	1.9 (0.8-4.6)
Area Type						
Tertile 1 (rural areas)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	0.7 (0.4-1.2)	0.6 (0.4-1.2)	0.6 (0.3-1.2)	0.6 (0.3-1.2)	0.8 (0.3-2.7)	0.8 (0.2-2.6)
Tertile 3(urban areas)	0.8 (0.5-1.3)	0.7 (0.4-1.2)	0.7 (0.4-1.1)	0.7 (0.4-1.2)	1.4 (0.5-3.9)	0.9 (0.3-2.5)
IRR[1] Unadjusted hazard ratios, effects of each variable before controlling for the effect of the other explanatory variables. IRR[2] Adjusted hazard ratios, adjusted effects after controlling for the effect of all the other explanatory variables.						

Table 4.6 Cox proportional hazard model stratified by gender

	All External Cause Deaths		Suicide Deaths		Non-Suicide External Cause Deaths	
	Males IRR[1] 95% CI	**Females IRR[1] 95% CI**	**Males IRR[1] 95% CI**	**Females IRR[1] 95% CI**	**Males IRR[1] 95% CI**	**Females IRR[1] 95% CI**
Age						
15-24	1.00	1.00	1.00	1.00	1.00	1.00
25-44	1.6 (1.2-2.2)	2.9 (1.7-5.1)	1.4 (1-2.1)	4.8 (2.1-10.7)	1.9 (1.2-3.2)	1.6 (0.7-3.5)
45-64	1.7 (1.2-2.4)	4.4 (2.5-7.9)	1.8 (1.2-2.8)	7.1 (3.1-16.3)	1.5 (0.8-2.8)	2.4 (1.1-5.6)
65+	1.5 (0.7-3.4)	3.7 (1.4-10.3)	1.4 (0.6-3.6)	6.5 (1.9-22.4)	1.8 (0.4-7.8)	1.4 (0.2-11.5)
Self-Harm Method						
Overdose only	1.00	1.00	1.00	1.00	1.00	1.00
Minor Cutting only	1.0 (0.6-1.5)	1.2 (0.6-2.5)	0.8 (0.4-1.5)	1.3 (0.5-3.5)	1.1 (0.6-2)	1.1 (0.4-3.2)
Overdose & cutting	0.8 (0.4-1.6)	2.1 (1-4.6)	1.0 (0.4-2.3)	2.2 (0.8-6.3)	0.6 (0.2-1.9)	1.9 (0.6-6.2)
Attempted hanging only	1.8 (1.2-2.8)	4.2 (2-8.9)	2.6 (1.6-4.3)	6.8 (3-15.7)	0.6 (0.2-1.8)	1.2 (0.2-8.7)
Attempted drowning only	1.1 (0.5-2.3)	1.7 (0.5-5.4)	1.9 (0.9-4.2)	2.0 (0.5-8.4)	-	1.4 (0.2-10)
All Other Methods	1.4 (1.0-2.1)	1.8 (0.9-3.4)	1.6 (1.0-2.5)	2.4 (1.1-5.1)	1.3 (0.7-2.3)	1.0 (0.3-3.4)
Major Cutting only	1.2 (0.7-2)	2.4 (1.1-5.3)	1.8 (1-3.2)	3.2 (1.3-8.3)	0.5 (0.1-1.5)	1.5 (0.3-6.3)
Poisoning only	1.9 (0.8-4.4)	2.3 (0.6-9.6)	2.8 (1.2-6.5)	1.6 (0.2-12)	-	4.1 (0.5-31.2)
Recommended Next care						
Not admitted	1.00	1.00	1.00	1.00	1.00	1.00
Admission ward	2.0 (1.5-2.6)	2.3 (1.5-3.6)	2.4 (1.7-3.4)	2.8 (1.6-4.9)	1.4 (0.9-2.3)	1.7 (0.9-3.4)
Admission psychiatry	0.9 (0.6-1.5)	1.9 (1.1-3.4)	1.2 (0.7-2)	1.7 (0.8-3.7)	0.5 (0.2-1.4)	2.2 (0.9-5.3)
Patient refused to be admitted	0.9 (0.2-3.5)	0.9 (0.1-6.5)	0.7 (0.1-4.9)	1.9 (0.2-14.1)	1.3 (0.2-9.5)	-
Left without being seen	1.5 (1.1-2.2)	0.8 (0.4-1.6)	1.4 (0.8-2.3)	0.7 (0.2-2)	1.6 (1-2.7)	0.9 (0.3-2.5)
Involvement of alcohol						
No Alcohol involved	1.00	1.00	1.00	1.00	1.00	1.00
Alcohol involved	0.8 (0.7-1.1)	0.9 (0.7-1.4)	0.7 (0.5-0.9)	0.6 (0.3-0.9)	1.2 (0.8-1.8)	2.0 (1.1-3.7)
Self-Harm Repetition						
No repeat act	1.00	1.00	1.00	1.00	1.00	1.00

1 repeat act	2.0 (1.4-2.7)	1.3 (0.7-2.3)	1.2 (0.8-2)	1.2 (0.6-2.5)	3.6 (2.3-5.7)	1.4 (0.5-3.7)
2 repeat act	2.4 (1.4-3.9)	5.4 (3.1-9.1)	2.0 (1.0-4.0)	3.1 (1.4-6.8)	3.0 (1.4-6.6)	10.2 (4.8-21.3)
3 or more repeat act	2.3 (1.2-4.4)	6.7 (3.8-12)	1.7 (0.7-4.1)	5.9 (2.7-12.6)	3.8 (1.5-9.5)	8.7 (3.5-21.6)
Socioeconomic Deprivation						
Tertile 1 (least deprived)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	0.8 (0.6-1.1)	0.6 (0.3-0.9)	1.0 (0.7-1.5)	0.6 (0.3-1.2)	0.4 (0.2-0.8)	0.5 (0.2-1.1)
Tertile 3 (most deprived)	0.7 (0.5-0.9)	0.8 (0.6-1.2)	0.8 (0.5-1.1)	1.0 (0.6-1.6)	0.6 (0.4-1)	0.6 (0.3-1.2)
Social Fragmentation						
Tertile 1 (least fragmented)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	1.4 (0.8-2.4)	1.1 (0.4-2.8)	1.5 (0.8-2.8)	0.9 (0.3-2.6)	1.1 (0.3-3.5)	1.8 (0.3-9)
Tertile 3 (most fragmented)	1.3 (0.8-2.2)	1.7 (0.7-4)	1.2 (0.6-2.3)	1.3 (0.5-3.4)	1.6 (0.5-4.5)	2.9 (0.6-13.7)
Area Type						
Tertile 1 (rural areas)	1.00	1.00	1.00	1.00	1.00	1.00
Tertile 2	0.9 (0.5-2)	0.3 (0.1-1)	0.9 (0.4-1.9)	0.2 (0.1-1)	1.8 (0.2-15.8)	0.6 (0.1-2.6)
Tertile 3 (most urban areas)	1.0 (0.5-1.9)	0.4 (0.2-0.9)	0.8 (0.4-1.7)	0.5 (0.2-1.3)	2.7 (0.4-20.1)	0.4 (0.1-1.3)
IRR[1]Adjusted hazard ratios, adjusted effects after controlling for the effect of all the other explanatory variables.						

Figure 4.1 Estimated survival probability of death from external causes by age and gender



Chapter 5

Brief overview of the literature – The ecological association between suicidal behaviour (deliberate self-harm and suicide) and area level factors

Introduction

To better understand the causes of suicidal behaviour, the area where individuals reside needs to be considered. Examining the geographic distribution of suicidal behaviour (both deliberate self-harm and suicide) may highlight inadequacies in mental health services and reveal a need for the targeting of mental health services in specific geographic areas.[122] Ecological studies of suicidal behaviour investigate how area level factors such as the compositional effects of persons residing in an area and the effects of physical characteristics and social interactions of an area influence the geographic distribution of suicide and deliberate self-harm.[123]

Studies examining the geographic variation of suicide have a long history; whereas studies investigating the geographic variation of deliberate self-harm are a relatively more recent phenomena. Since the late 19th century, studies carried out by Morselli,[124] and Durkheim[125] in particular, have examined the geographic variation of suicide both within and across countries in Europe. Morselli's investigation of suicide included detailed maps of rates across Europe as a whole, as well as within the countries of England, Italy and France. Durkheim built upon the findings from Morselli's previous work and examined to what extent the spatial patterning of factors such as levels of alcoholism, wealth and family size could explain the spatial patterning of suicide in France. Durkheim postulated that high suicide rates may be attributed to poor social regulation (i.e. the extent to which individuals are integrated into society). Durkheim believed that societies that had strong social bonds had low rates of suicide, and that poverty might even act as a protective factor against suicide

Deprivation and social fragmentation are two area level constructs that have been extensively studied to explain the spatial variation of suicide and deliberate self-harm. Although deprivation and social fragmentation indices are highly correlated, they are conceptually distinct constructs. Deprivation indices mainly capture the material disadvantage of an area, whereas social fragmentation indices capture the level social integration in an area.[126]

Socioeconomic deprivation indices

It is widely accepted that area level socioeconomic deprivation is strongly associated with mortality from most common diseases.[127] Moreover, mortality also tends to be higher in socioeconomically deprived areas regardless of the socioeconomic position of the individual persons residing in an area.[128] Deprivation indices are an objective measure of the relative affluence or deprivation of an area. Deprivation indices are based on a number of social and economic variables usually derived from the Census of Population, from which a single score is calculated which can then be used to provide a ranking of individual areas. There are a number of deprivation indices, most of which are from the United Kingdom. These include the Carstairs and Morris Index in Scotland, the Townsend Index and Index of Deprivation in England, and the Index of Relative Deprivation in Northern Ireland. Indices have also been developed in New Zealand and America. In Ireland, Deprivation indices include the Irish National Deprivation Index for Health and the more recent Pobal HP Deprivation Index.

Social Fragmentation Score

The anomie or social fragmentation score was developed by Congdon[104] and refers to the lack of social integration of an individual into society. Congdon developed his social fragmentation score to test Durkheim's theory of social causation. It has been suggested that socially fragmented areas have less stable social institutions and social bonds. Stable institutions and social bonds are needed to promote permanency in social connections and facilitate access to resources that promote healthy behaviours and good physical and mental health.[126] Congdon found that social fragmentation was a better area level predictor of suicide and deliberate incidence than the Townsend index of deprivation in local authority areas in London.

Summary of findings from ecological studies examining the association between suicide and area level factors

A considerable number of studies have examined the association between suicide and area level risk factors, however, the findings of these studies have been somewhat divergent. A systematic review by Rehkopf and Buka of 86 studies involving 221 separate analyses found that the overall results were mixed but tended toward showing that increased socioeconomic deprivation was associated with an increased risk of suicide.[129] Almost half of the 221 analyses reported a significant association between increasing levels of socioeconomic deprivation and suicide. However, certain studies found no association between area level socioeconomic deprivation and suicide.[130-133] While other studies showed that social fragmentation had a stronger association with suicide risk than socioeconomic deprivation.[127, 128, 134, 135]

Furthermore, some of these studies found that the association between suicide and social fragmentation varied by age and gender. For example, Evans et al.[134] found that the association between suicide and social fragmentation was strongest in younger persons, whereas Whitley et al. other studies found that effect of social fragmentation was similar across all age groups.[127]

Summary of findings from ecological studies examining the association between self-harm and area level factors

As discussed previously, there is extensive literature examining the relationship between suicide and area level determinants, however a relatively small number of studies have examined this association in relation to deliberate self-harm. A review of the literature conducted by Burrows & Laflamme in 2010, confirmed this by showing that only thirteen studies had examined this ecological association between self-harm and area level risk factors.[136] Overall, the review found that increased area level socioeconomic disadvantage was associated with increased self-harm incidence, however this relationship was not found across all studies. Some studies found that the relationship between self-harm and deprivation was stronger in males,[104] whereas other studies found the association was stronger in females.[137] Furthermore, other studies showed effect modification by age, with the effect of socioeconomic deprivation only being found among younger self harm populations.[130, 138] Also, some studies found that socioeconomic deprivation had a stronger effect compared to social fragmentation.[137, 139]

Gap in research knowledge – Existing studies examining association between self-harm and area level measures in Ireland

In Ireland only one national study by Corcoran et al.[116] has examined the association between hospital treated self-harm and area level risk factors. This study found that there were striking geographic variations in deliberate self-harm rates, with the highest rates of hospital-treated deliberate self-harm being found in deprived urban areas. This study was based on self-harm data for the years 2001-2003, this was during the pre-recession Celtic Tiger era in Ireland. It is plausible that the nature of the relationship between self-harm and area level determinants may have changed in the years following the recession as social and economic conditions may have changed. Therefore, large scale up-to-date national studies examining the relationship between area level factors and self-harm incidence need to be carried out.

Furthermore, since the publication of this study by Corcoran et al. a new Irish deprivation index called The Pobal HP Deprivation Index has been developed.[103] One of the main weaknesses of the deprivation index used in the study by Corcoran et al. and the various European deprivation indices used in studies conducted elsewhere, is that these deprivation indices were primarily designed to capture deprivation in urban settings. Indicators that capture deprivation in urban areas may not adequately reflect deprivation in rural areas, as certain problems such as access to health services, job opportunities and population mobility can disproportionally affect rural people.[140] The HP Pobal Deprivation Index aims to address this issue as it

includes a specific measure of rural socioeconomic deprivation (demographic decline), which the authors of this index argue is the most representative measure of rural socioeconomic deprivation.

Lastly, previous research has shown that self-harm incidence is largely an urban phenomena, yet to date no study in Ireland or elsewhere, has established to what extent the high incidence of hospital treated self-harm in urban areas can be explained by the fact that hospitals tend to located in urban areas.

Therefore, to address this gap in research knowledge, this thesis will:

(1) Examine the small area level association between deliberate self-harm and the area level factors, deprivation, social fragmentation and population density during the period 2009-2011.
(2) Examine how travel time to the nearest hospital emergency department influences area level incidence rates of self-harm.

Gap in research knowledge – Existing studies examining association between suicide and area level measures in Ireland

In Ireland, there is considerable geographic variation in the rates of suicide. However, there is a paucity of studies investigating the spatial disparities of suicide in the Republic of Ireland. One of the first studies to explore this phenomenon carried out by McCarthy et al., examined rates of suicide in Dublin City and County over a 10 year period from 1954 to 1963.[9] McCarthy et al. showed that the highest rates of suicide occurred in central parts of

Dublin city which the authors concluded were “central disorganised areas with large numbers of people living in social isolation”. Another study by Kelleher et al. found that from 1980 to 1990 the Irish male suicide rate increased by 50% in rural areas while there was no increase in the male suicide rate in urban areas.[141] Clarke et al. also found this persistence of higher rates of suicide in males from rural areas than males from urban areas.[142] Connolly and Lester examined the correlation between suicide and socio-demographic determinants (such as GDP, unemployment rate, expenditure, marriage rate, crime rate) at county level and found no association between suicide risk and sociodemographic factors except for crime.[143] In all of these studies by McCathy et al., Kelleher et al., Clarke et al. and Connolly and Lester the geographic unit of analysis was large. It has been demonstrated that the findings of ecological studies depends on the scale of population aggregation. If the unit of analysis is too big there is the possibility that the underlying population may be too heterogeneous and effects measured at the aggregate level will differ when measured at the individual level.[144] This highlights the need for a study in to be carried out in the Republic of Ireland to examine the association between suicide risk and area level determinants at a more meaningful small scale geography level.

Therefore, to address this gap in research knowledge, this thesis will:

1) Examine the small area level association between suicide and the following three area level factors, socioeconomic deprivation, social fragmentation and population density during the period 2009-2011.

Chapter 6(a)

Characteristics of small areas with high rates of hospital-treated self-harm: Deprived, fragmented and urban or just close to hospital? A national registry study

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Abstract

Background

Previous research has shown an inconsistent relationship between the spatial distribution of hospital treated self-harm and area-level factors such as socioeconomic deprivation and social fragmentation. However, many of these studies have been confined to urban centres, with few focusing on rural settings and even fewer studies carried out at a national level. Furthermore, no previous research has investigated if travel time to hospital services can explain the area-level variation in the incidence of hospital treated self-harm.

Methods

From 2009 to 2011, the Irish National Registry of Deliberate Self Harm collected data on self-harm presentations to all hospital emergency departments in the country. The Registry uses standard methods of case ascertainment and also geocodes patient addresses to small area geographical level. Negative binomial regression was used to explore the ecological relationship between area level self-harm rates and various area-level factors.

Results

Socioeconomic deprivation, social fragmentation and population density had a positive linear association with self-harm, with socioeconomic deprivation having the strongest independent effect. Furthermore, self-harm incidence was found to be elevated in areas that had shorter journey times to hospital.

However, while this association became attenuated after controlling for other area-level factors it still remained statistically significant. A subgroup analysis examining the effect of travel time on specific methods of self-harm, found that this effect was most marked for self-harm acts involving minor self-cutting.

Conclusions

Self-harm incidence was influenced by proximity to hospital services, population density and social fragmentation; however, the strongest area-level predictor of self-harm was socioeconomic deprivation.

Introduction

Individual level risk factors for self-harm include, psychiatric illness, youth, female sex, marital status, socioeconomic disadvantage, adverse life events (particularly in childhood), social isolation and sexual orientation.[12] Knowledge of these individual level risk factors alone has limits for informing strategies aimed at preventing suicidal behaviour, and may potentially mask more distal and conceivably fundamental causes of suicidal behaviour.[145] To better understand the causes of suicidal behaviour the characteristics of the areas in which people reside need to be examined also. An ecological perspective on self-harm examines how area level characteristics such as socioeconomic deprivation and social fragmentation influence small area rates of self-harm.

Previous research has shown an inconsistent relationship between the spatial distribution of hospital treated deliberate self-harm and area level factors such as socioeconomic deprivation and social fragmentation. A review of the literature conducted by Burrows & Laflamme in 2010,[136] found that a limited number of studies (N=13) had examined this ecological association between self-harm and area level risk factors. Overall, the review found that increased area level socioeconomic disadvantage was associated with increased self-harm incidence, however this relationship was not found across all studies. Some of the studies in the review found that the relationship between increased levels of socioeconomic deprivation and increased levels of self-harm was stronger in males whereas other studies found the effect of socioeconomic deprivation was stronger in females.[137] Furthermore, some studies found the effect of socioeconomic deprivation

was only seen in younger self harm populations.[130, 138] Other studies found that socioeconomic deprivation had a stronger effect compared to social fragmentation.[116, 137]

However, many of these studies are confined to urban centres, with few focusing on rural settings and even fewer studies being carried out at a national level. Only one previous study based on self-harm data for the years 2001-2003, was carried out a national level during the pre-recession Celtic Tiger era in Ireland.[116]

Therefore, large scale up-to-date national studies examining the relationship between area level factors and self-harm incidence are lacking.

Furthermore, no previous study has examined the effect of proximity to hospital services on the incidence of self-harm as it has been suggested that the high rates of self-harm in urban centres may be explained by the fact that hospital services are typically located in urban centres. To our knowledge, this is the first study to examine how travel time to the nearest hospital emergency department influences area level incidence rates of self-harm.

This study aims to investigate the area level relationship between hospital treated deliberate self-harm, and the following area constructs: socioeconomic deprivation, social fragmentation, population density and in particular, travel time to the nearest hospital emergency department in the Republic of Ireland (ROI).

Methods

Setting

According to the National Census conducted in 2011 the population of the ROI was 4,588,252. The population increased by 8.2% since the previous Census in 2006. Ireland consists of 26 counties and 3,409 small areas known as district electoral divisions (DEDs). These 3,409 DEDs will be the unit of analysis in this study. There are five cities in the ROI, of which Dublin is the largest with a population of 527,612. The majority of the county of Dublin is urbanised, with almost 28% of population residing in this county. The four other cities (Cork, Limerick, Galway and Waterford) are made up of 171 DEDs and together account for 7% (298,597) of the population.

Self-Harm Data – The Irish National Registry of Deliberate Self Harm

Data on deliberate self-harm for the years 2009 to 2011 was taken from the National Registry of Deliberate Self Harm Ireland. Details of the Registry's case definition and case ascertainment have been previously described in the study by Perry et al.[23] The Registry is a national system that records and monitors all the self-harm presentations made to each acute hospital across the country.

Data on self-harm presentations are collected by dedicated data registration officers who operate independently of the hospitals and there is standardised application of case definition and inclusion/exclusion criteria. The case definition of self-harm used by the Registry is one that has been developed by the former WHO/Multi-centre Study on Parasuicide and has been widely

applied in research.[89] The Registry geocodes the addresses recorded for every self-harm patient to electoral division level.

Socioeconomic Deprivation

An Irish socioeconomic deprivation index known as The Pobal HP Deprivation Index was used in this study.[103] Most other commonly used socioeconomic deprivation indices are based on a factor analytical approach which reduces a larger number of indicator variables to a smaller number of underlying dimensions or factors. The Pobal HP Deprivation Index does not allow the definition of the underlying dimensions of socioeconomic deprivation to be determined by data-driven techniques, but instead the authors of this index develop a prior conceptualisation of these dimensions. The HP Index draws on ten indicators taken from the 2011 Census to express a combination of three dimensions of affluence and socioeconomic deprivation: (a) Demographic Profile, (b) Social Class Composition and (c) Labour Market Situation. The 10 census indicators include; (1) % change in population over the previous five years; (2) % of persons aged under 15 or over 64 years of age; (3) % of persons with a primary school education only; (4) % of persons with a third-level education; (5) mean number of persons per room; (6) % of households headed by professionals or managerial and technical employees; (7) % of households headed by semiskilled or unskilled manual workers; (8) % of households with children aged under 15 years and headed by a single parent; (9) male unemployment rate and (10) female unemployment rate. It has been argued that widely used socioeconomic deprivation indices such as the Index of Multiple Deprivation (IMD) and the Townsend Score have an urban bias as they were designed to measure

urban deprivation, therefore such indices may fail to capture rural deprivation.[129] As Ireland has a considerable rural population, it is particularly important for a socioeconomic deprivation index to be capable of capturing urban and rural socioeconomic deprivation. The authors of the HP Deprivation Index state that demographic decline which is measured by emigration (the percentage change in population over 5 years), the concentration of economically dependent individuals (the percentage of population aged under 16 or over 65 years) as well as those with lower levels of education (percentage of population with primary school education) is the most representative measure of rural socioeconomic deprivation. DEDs were divided into quintiles based on their HP deprivation score with quintile 1 containing 20% of the least deprived areas and quintile 5 containing 20% of the most deprived areas.

Social Fragmentation

The measure of social fragmentation used in this study was based on Congdon's anomie score.[104] The following four indicators were taken from 2011 Irish Census; the percentage of unmarried adults; the percentage of single person households; the percentage of persons in private rented accommodation and the percentage of persons at a different address one year before the 2011 Census. Congdon's measure of social fragmentation was calculated for all small areas by summing the z-scores of each indicator. DEDs were divided into quintiles based on their fragmentation score, with quintile 1 containing 20% of the least socially fragmented areas and quintile 5 containing 20% of the most fragmented areas.

Population Density - Area Type

In this study, urban and rural small areas were distinguished by population density. DEDs were divided into quintiles based on their population density, with quintile 1 (rural areas) containing 20% of DEDs with the lowest population density and quintile 5 containing 20% of the most densely populated DEDs (urban areas).

Travel Time to Nearest Hospital

In Ireland, the All-Island Research Observatory (AIRO) calculated the journey times to all hospital emergency departments for every residential address point based on average drive-time speeds (average speed on NAVTEC road network plus 10% urban area congestion weighting).[146] For the purpose of this study the journey times have been averaged at the DED level. DEDs were divided into quintiles based on their distance in minutes from hospital, with quintile 1 containing 20% of DEDs with that had the shortest journey times and quintile 5 containing 20% of the DEDs with that had the longest journey times.

Statistical Analyses

Self-harm patients with non-household residential addresses such as hospital in-patients, prisoners and the homeless were excluded from this study. During the study time period, the Registry recorded that 1,312 (6%) self-harm patients had a non-household residential address. A considerable proportion of hospital treated self-harm presentations are due to repeat acts, therefore the number of individuals rather than the number of presentations was used in this study. As there were a limited number of self-harm cases in

children and older adults the study population was restricted to the 15 to 64 year old age group.

Initially, Poisson regression was carried out and it was found the conditional variance was greater than the conditional mean, which indicated that there may be the presence of over dispersion. Because of this, the negative binomial regression model was considered to be a better fit. All Poisson and negative binomial regression analyses were carried out using Stata 12.[105]

Negative binomial regression was used to investigate the area level relationship between self-harm and the various area level risk factors. In each of the models adjustment for spatial autocorrelation was made by indicating that the DEDs were clustered by county.

The associations with each of the area level explanatory variables before and after controlling for the effect of all the other variables were investigated. In the multivariate regression model, the individual components parts that make up both the aggregate socioeconomic deprivation and social fragmentation measures were excluded when examining the effects of the aggregate measures themselves.

Wald tests were used to determine the effect modification by age and gender for each of the four area level explanatory variables. Negative binomial models were also carried out separately for males and females aged 15-39 years and 40-64 years. In each analysis, the lowest quintile (quintile 1) was taken as the reference group. Estimated effects were given as incidence rate ratios with 95% confidence intervals. In addition to this, negative binomial regression analysis was carried out to examine the effect of how proximity to

the nearest hospital department impacted on the method of self-harm seen in hospital emergency departments. Because the co-variates population density and distance from hospital are highly correlated with one another, population density was omitted from multi-variate analysis. As overdose and self-cutting are the most common types of hospital treated self-harm seen in Ireland,[23] the impact of travel time on the incidence of these two self-harm methods was examined. Furthermore, the severity of the self–harm method was examined by distinguishing between major and minor self-cutting and overdoses that involved less than 20 tablets and overdoses that involved greater than 20 tablets.

Results

Table 6.1 provides a summary of the number of hospital treated self-harm patients, the population aged between 15 and 64 years and the four area level variables, in addition to the individual census indicator components that make up the social fragmentation index and socioeconomic deprivation index.

From 2009 to 2011, a total of 26,379 persons aged 15-64 years presented with self-harm. Over the 3 year study time period, the number of hospital treated self-harm patients ranged from 0 to 220 across the DEDs. In all, 981 (29%) of DEDs reported zero persons with hospital treated self-harm. The population aged 15-64 years in each DED varied greatly across the country with some DEDs having a population as small as 44 and other areas having a population in excess of 24,674. The population density ranged from 0.6 per km^2 to 1862 per km^2, the socioeconomic deprivation score ranged from -

35.51 to 18.7 and the social fragmentation score ranged from -6.3 to 21.3. The journey times to the nearest hospital ranged from 5.4 minutes to 232.1 minutes.

Incidence rates

From 2009 to 2011, an estimated 26,379 persons aged 15-64 years presented with self-harm (Table 6.2). The pooled 2009-2011 all person, male and female incidence rates were 286, 273 and 300 per 100000, respectively. Across both genders, the self-harm rates were highest in the year 2010 and lowest in 2009. Overall, the rate of self-harm in females was 10% higher than in males.

Area level self-harm rates and their ecological relationship with area level factors

Table 6.3 shows both the unadjusted and adjusted rate ratios for self-harm in all persons aged 15-64 years. In both the unadjusted and adjusted analyses, a positive linear association was found between increasing self-harm incidence and increasing levels of socioeconomic deprivation, social fragmentation and population density. The findings from the analysis of the subcomponents of socioeconomic deprivation and fragmentation composite measures showed a largely linear association with the exception of age dependency (the percentage of population age under 15 or over 64 years of age) and five year population change. However, results from the multivariate analysis found that only three of the sub components of socioeconomic deprivation index, namely five year population change, the proportion of lone parent households and male and female unemployment rate remained statistically significant. A significant association was found between self-

harm incidence and travel to hospital, with self-harm being most elevated in areas nearest to hospital services. Even though this association remained statistically significant after adjustment for the other explanatory variables, the strength of the association was reduced. Overall, socioeconomic deprivation had the strongest independent effect on small area self-harm incidence.

The effect of proximity to nearest hospital on method of self-harm

In Table 6.4 the findings from the negative binomial model on the effect of travel time to the nearest hospital department (after controlling for socioeconomic deprivation and fragmentation) on the method of self-harm seen at the emergency department are shown. The greatest impact was seen in self-harm acts involving self-cutting, in particular, minor self-cutting, with rates being highest in areas located very close to hospital services.

Stratification by age and gender

Effect modification by age and gender was examined for each of the four area level factors and it was found that the strength of the association between self-harm and the various area level factors differed between the younger and older age groups and between males and females. In Table 6.5 the effects of the area level factors on DED rates of self-harm stratified by age and gender is shown. Increasing socioeconomic deprivation had a greater effect on self-harm incidence in the younger age group (χ^2=19.92, P<0.01) whereas increased social fragmentation had a greater effect of self-harm incidence in the older group (χ^2=18.64, P<0.01). Moreover, a significant interaction between gender and population density was also found

(χ^2= 18.26, P<0.01), with greater levels of population density having a stronger effect on self-harm in males

Discussion

Main findings

The results of our study show that socioeconomic deprivation is the strongest independent area level predictor of self-harm and this finding is consistent with earlier studies.[116, 137, 147] Socioeconomic deprivation was also found to have the greatest effect in the younger age group than the older age group, this is also in line with previous research.[130] Moreover, the linear association between increasing incidence of self-harm and increasing levels of population density are also consistent with previous studies carried in the other countries such as the United Kingdom,[148] America[149] and Finland.[51] We found that the effect of fragmentation was modified by age with stronger effects been found in the older age groups and this finding is in line with previous research.[116] However, the relationship between self-harm and fragmentation was weakened after adjustment for the other area level explanatory variables, and again this finding is in agreement with previous studies.[116, 137]

This is the first study to investigate how travel time to the nearest hospital department helps to explain the area level variation of self-harm. It has been suggested that because hospitals are mainly situated in urban areas, the high rates of self-harm in city/urban areas may be in part explained by proximity to hospital services.[116] The study findings have shown a significant

independent association between self-harm incidence and travel time to hospital. In particular, when examining the effect of proximity to hospital on the various methods of self-harm a striking association was found for minor self-cutting hospital presentations, with minor-self cutting presentations being highest in areas that are located nearest to hospital services. In Ireland, hospital services tend to be located in urban areas, resulting in persons from rural areas having to travel greater distances to reach the nearest hospital. Our findings may suggest that in Ireland, the overall incidence of self-harm and in particular, hospital treated self-cutting, may be underestimated and that the lower incidence of self-cutting in rural areas may only be artificially low due to greater distance from hospital services acting as a potential barrier deterring individuals who self-harm residing in rural locations from attending hospital. Alternatively, the lower incidence of minor self-cutting found in rural areas may support the conclusions from other research that individuals who self-harm living in rural areas have higher levels of suicidal intent and that an episode of self-harm is more likely to be an act of attempted suicide. Consequently this group are less likely to engage in more lethal or severe methods of self-harm such as minor self-cutting.[148]

Strengths and Limitations

A major strength of the study is that it is based on national Registry data that includes 26,379 persons over a 3 year period. The HP Pobal Deprivation Index (as used in this study) is unique compared to other European socioeconomic deprivation indices, as it includes a specific measure of rural socioeconomic deprivation.[150] It has been suggested in the literature that the use of socioeconomic deprivation composite measures may fail to identify

rural socioeconomic deprivation at small area geography level.[151] In the HP Pobal Deprivation Index, one of the three dimensions of socioeconomic deprivation is concerned with demographic decline; the authors of this deprivation index argue that demographic decline is the most representative measure of rural socioeconomic deprivation.

A weakness of the study is that the lack of adequate geographical information systems in Ireland compromises the Registry's ability to accurately geocode patient addresses to DED level.[116] The boundaries of these DEDs have not changed in many years, and because of Ireland's increasing urbanisation and rapidly changing settlement patterns, these DEDs can range in size from as little as 100 persons to as much as 32,000 persons. Furthermore, statistical techniques such as multi-level modelling cannot be carried out as the Registry does not collect individual level data on socioeconomic status. This study only examines hospital treated self-harm, therefore our results may not generalisable to self-harm cases in the general population as the risk factors and profiles of these individuals may be different. The distance decay effect is a geographical term that can be used to describe the interaction between distance and healthcare service utilisation. The distance decay effect is where levels of health services usage decreases as distance from the actual location of the healthcare facility increases. Previous research has found that distance is an important factor in determining health services utilisation.[152, 153] As the distance decay effect is primarily an expression of healthcare utilisation, it cannot be interpreted as an indicator of healthcare need, so caution needs to be taken when

interpreting our study findings that have shown that self-harm rates are most elevated in areas that have the shortest travel time to hospital services.

This is the first study to investigate how travel time to the nearest hospital department influences the geographic variation of hospital treated self-harm. Our findings highlight that persons living greater distances from hospital may be failing to seek hospital treatment for self-harm as increased journey times to hospital services may be acting as a potential deterrent. This poses a potential challenge for health services as this subgroup of the self-harm population may be going undetected and are consequently not receiving the necessary aftercare treatment. While it may be argued that persons engaging in self-harm from remote and rural areas may be accessing local primary care services instead of attending hospital services, data to confirm this possibility are lacking.

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Contributors

IJP and PC designed the Registry on which the report is based. IBOF, PC and IJP conceived and designed the study. IBOF wrote the initial and subsequent drafts of the manuscripts and PC and IJP revised the manuscript critically for important intellectual content. IBOF carried out the data analysis. All authors have seen and approved the final version of the report.

Competing Interests

None.

Ethical Approval

Ethical approval for the Registry was granted by the Irish National Research Ethics Committee of the Faculty of Public Health Medicine. The National Suicide Research Foundation is registered with the Data Protection Agency and complies with the Irish Data Protection Act of 1988 and the Irish Data Protection (Amendment) Act of 2003.

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Provenance and peer review

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Table 6.1 Summary statistics for all 3,409 district electoral divisions (DEDs) in the Republic of Ireland number from 2009-2011

	Mean	Std. Dev.	Min	Max
Population aged 15-64 years per DED	901.5	1509.5	44.0	24674
Population Density per DED	692.5	1826.1	0.6	18792
Social Fragmentation Composite Score per DED	7.2	3.3	-6.3	21.3
Individual Social Fragmentation Indicators:				
Unmarried persons (%)	60	5.6	41.3	87.9
One person households (%)	23.6	7.2	2.3	73.2
Population Mobility (%)	5.3	3.9	0.0	37.1
Households privately rented (%	10.5	11.1	0.0	89.4
Pobal HP Deprivation Index Composite Score per DED	-8.5	6.3	-35.5	18.7
Individual Deprivation Indicators:				
5-Year Population Change (%)	7.8	13.0	-43.7	185.7
Age dependency rate	34.9	4.6	8.2	50.8
Lone parents rate	16.3	11.0	0.0	75.0
Primary education only (%)	18.8	7.4	1.1	53.6
Third level education (%)	25.9	10.2	1.4	84.0
Higher and lower professionals (%)	33.7	9.8	4.1	71.9
Semi and unskilled manual workers (%)	18.2	6.4	2.4	51.0
Unemployment rate - male	21.7	8.3	0.0	65.8
Unemployment rate - female	13.8	6.3	0.0	50.6
Average persons per room	0.5	0.1	0.3	1.3
Travel time in minutes to nearest hospital per DED	26.5	13.7	5.4	232.1
Self-harm patients aged 15-64 years in 2009 per DED	5.0	6.8	1	66
Self-harm patients aged 15-64 years in 2010 per DED	5.1	7.1	1	77
Self-harm patients aged 15-64 years in 2011 per DED	5.2	7.3	1	77
Self-harm patients aged 15-64 years in 2009-2011 per DED	10.9	18.4	1	220

**The age dependency rate refers to the percentage of population age under 15 or over 64 years of age*

Table 6.2 The 2009 – 2011 annual incidences of self-harm in the Republic of Ireland

	Males		Females		Persons	
	N	Rate	N	Rate	N	Rate
2009	4056	265	4470	289	8526	277
2010	4235	277	4763	308	8998	293
2011	4203	275	4652	301	8855	288
2009-2011	12494	273	13885	300	26379	286

Table 6.3 Effects of socioeconomic deprivation, social fragmentation, population density and travel time to nearest hospital emergency department on electoral division rates in persons aged 15-64 years

	Unadjusted IRR[1] 95% CI				Adjusted IRR[2] 95% CI			
	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Socioeconomic deprivation Score	1.0 0.97-1.13	1.2 1.03-1.29	1.3 1.09-1.56	2.1 1.75-2.57	1.4 1.29-1.57	1.6 1.46-1.8	1.8 1.59-2.02	2.5 2.17-2.83
5 year population change (Q5 highest population decline)	1.0 0.92-1.12	1.1 0.96-1.15	1.2 1.07-1.25	1.7 1.49-2.04	1.1 1.03-1.18	1.1 1.06-1.24	1.1 1.07-1.22	1.3 1.16-1.36
***Age dependency rate**	0.8 0.73-0.91	0.8 0.69-0.86	0.7 0.66-0.83	0.7 0.59-0.76	1.0 0.95-1.08	1 .0 0.95-1.08	1.1 1.05-1.17	1.1 0.99-1.14
Lone parents rate	1.2 1.05-1.4	1.4 1.22-1.55	2.0 1.69-2.34	3.7 3.13-4.45	1.1 0.92-1.24	1.1 0.99-1.24	1.2 1.06-1.45	1.4 1.15-1.62
Primary education only	1.1 1.02-1.26	1.2 1.04-1.29	1.3 1.11-1.49	1.8 1.38-2.35	1.1 1.02-1.15	1.0 0.93-1.13	1.0 0.91-1.1	1.1 0.9-1.24
Third level education (Q5 lowest % in third level education only)	1.0 0.91-1.17	1.0 0.89-1.23	1.1 0.93-1.29	1.7 1.39-2.03	1.1 0.98-1.16	1.0 0.88-1.12	1.0 0.86-1.19	1.1 0.92-1.28
Professionals (Q5 lowest % of professionals)	1.1 0.97-1.16	1.3 1.21-1.38	1.5 1.37-1.64	2.6 2.21-3.01	1.0 0.88-1.11	1.0 0.87-1.15	0.9 0.77-1.07	1.0 0.84-1.18
Manual workers	1.2 1.05-1.26	1.2 1.14-1.33	1.6 1.49-1.81	2.6 2.19-3.11	1.1 1.0-1.23	1.1 0.94-1.28	1.2 0.99-1.42	1.3 1.08-1.63
Unemployment rate - male	1.2 1.09-1.36	1.5 1.29-1.67	1.9 1.55-2.23	2.9 2.4-3.6	1.1 1.04-1.21	1.2 1.09-1.38	1.3 1.11-1.48	1.3 1.1-1.51
Unemployment rate - female	1.2 1.09-1.34	1.5 1.34-1.68	1.8 1.57-2.1	3.1 2.59-3.61	1.1 1.01-1.22	1.1 0.98-1.24	1.2 1.01-1.35	1.4 1.15-1.69
Persons per room	1.0 0.91-1.17	1.0 0.91-1.18	1.3 1.16-1.45	1.9 1.6-2.25	1.0 0.90-1.09	1.0 0.86-1.05	1.0 0.85-1.09	1.0 0.83-1.14
Fragmentation Score	1.2 1.1-1.4	1.4 1.28-1.6	2.0 1.69-2.27	3.0 2.49-3.72	1.1 1-1.27	1.2 1.07-1.34	1.4 1.22-1.52	1.7 1.47-1.87
Unmarried persons	1.1 0.98-1.17	1.3 1.12-1.4	1.6 1.45-1.84	3 2.57-3.58	0.9 0.88-1.02	1.0 0.87-1.1	1.0 0.90-1.16	1.1 0.99-1.3
One person households	1.0 0.86-1.16	1.1 0.98-1.34	1.4 1.15-1.67	1.9 1.58-2.39	1.0 0.92-1.0	1.0 0.90-1.08	1.1 0.92-1.27	1.2 1.01-1.39
Population mobility	1.3 1.12-1.51	1.3 1.09-1.62	1.5 1.26-1.85	2.0 1.59-2.41	1.0 0.90-1.18	1.0 0.86-1.17	1.0 0.85-1.14	0.9 0.77-1.09
Privately rented households	1.2 0.92-1.46	1.6 1.2-2.14	1.9 1.49-2.46	2.5 2.03-3.05	0.9 0.78-1.13	1.0 0.86-1.23	1.1 0.9-1.34	1.1 0.91-1.38
Population Density	1.2 0.97-1.46	1.3 1.08-1.63	1.8 1.42-2.4	3.2 2.44-4.3	1.2 1.0-1.52	1.4 1.16-1.68	1.7 1.42-2.14	2.3 1.84-2.79
Travel time to hospital	0.5 0.44-0.65	0.6 0.46-0.68	0.6 0.46-0.7	0.5 0.44-0.65	0.9 0.78-0.94	0.8 0.73-0.93	0.8 0.71-0.92	0.8 0.69-0.89

[1]Unadjusted effects of each area level variables before controlling for the effect of the other explanatory variables.
[2] Adjusted effects after controlling for the effect of all the other explanatory variables including age and gender. The individual components parts of the aggregate socioeconomic deprivation and social fragmentation measures were excluded when examining the effects of the aggregate measures themselves.
***The age dependency rate refers to the percentage of population age under 15 or over 64 years of age**

Table 6.4 Effects of travel time to nearest hospital on specific methods of self-harm

	Unadjusted IRR[1] 95% CI				Adjusted IRR[2] 95% CI			
	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Quintile 2	Quintile 3	Quintile 4	Quintile 5
All methods of self-harm	0.5 0.4-0.62	0.5 0.42-0.64	0.5 0.41-0.65	0.5 0.39-0.61	0.8 0.68-0.83	0.7 0.59-0.74	0.6 0.55-0.72	0.6 0.51-0.64
Overdose (<20 tablets)	0.6 0.49-0.78	0.6 0.42-0.75	0.6 0.46-0.77	0.7 0.5-0.87	0.9 0.79-1	0.8 0.7-0.93	0.7 0.63-0.85	0.7 0.57-0.78
Overdose (>20 tablets)	0.6 0.52-0.76	0.6 0.54-0.77	0.7 0.54-0.79	0.6 0.53-0.79	0.8 0.75-0.95	0.7 0.64-0.82	0.7 0.62-0.82	0.7 0.57-0.76
Minor Self-Cutting	0.5 0.36-0.7	0.4 0.29-0.63	0.5 0.35-0.72	0.4 0.31-0.62	0.7 0.59-0.93	0.5 0.35-0.7	0.5 0.39-0.73	0.5 0.35-0.63
Major Self-Cutting	0.5 0.39-0.65	0.5 0.37-0.71	0.5 0.36-0.61	0.5 0.39-0.71	0.8 0.6-0.97	0.6 0.44-0.78	0.5 0.38-0.62	0.5 0.42-0.71

[1]Unadjusted effects of each area level variables before controlling for the effect of the other explanatory variables.
[2]Adjusted effects after controlling for the effect of socioeconomic deprivation social fragmentation, age and gender – population density was omitted as population and distance to hospital were highly correlated with one another.

Table 6.5 Stratified by age and gender- The effects of socioeconomic deprivation, fragmentation, population density and travel time to nearest hospital on DED self-harm rates

Explanatory Variable	Males 15-39 yr olds IRR[1] (95%CI)	Males 40-64 yr olds IRR[1] (95%CI)	Females 15-39 yr olds IRR[1] (95%CI)	Females 40-64 yr olds IRR[1] (95%CI)
Socioeconomic deprivation (Reference category 1st quintile- least deprived)				
2nd Quintile	1.5*** (1.31-1.77)	1.4*** (1.17-1.61)	1.5*** (1.29-1.68)	1.2** (1.08-1.44)
3rd Quintile	1.7*** (1.48-2.01)	1.6*** (1.37-1.95)	1.6*** (1.41-1.89)	1.5*** (1.3-1.67)
4th Quintile	1.9*** (1.63-2.21)	1.9*** (1.5-2.32)	1.7*** (1.47-1.96)	1.7*** (1.46-1.99)
5th Quintile	2.9*** (2.31-3.58)	2.3*** (1.97-2.8)	2.5*** (2.1-2.89)	2.1*** (1.82-2.48)
Social Fragmentation (Reference category 1st quintile - least fragmented)				
2nd Quintile	1.1 (0.94-1.34)	1.3* (1.05-1.49)	1.1 (0.93-1.25)	1.1 (0.91-1.4)
3rd Quintile	1.2 (0.97-1.39)	1.3*** (1.14-1.52)	1.1 (0.93-1.37)	1.3* (1.03-1.52)
4th Quintile	1.4*** (1.18-1.55)	1.6*** (1.4-1.89)	1.2* (1.03-1.43)	1.4** (1.17-1.79)
5th Quintile	1.5*** (1.3-1.82)	2.3*** (1.91-2.72)	1.4** (1.14-1.67)	1.9*** (1.53-2.27)
Population Density (Reference category 1st quintile - most rural)				
2nd Quintile	1.2 (0.79-1.77)	1.4* (1.02-1.96)	1.3* (1.02-1.55)	1.1 (0.79-1.57)
3rd Quintile	1.4** (1.11-1.86)	1.6** (1.14-2.17)	1.3 (1-1.67)	1.4* (1.03-1.81)
4th Quintile	1.8*** (1.34-2.42)	2*** (1.59-2.59)	1.6*** (1.25-2.09)	1.7** (1.19-2.37)
5th Quintile	2.2*** (1.56-3.14)	2.7*** (2.09-3.4)	2.1*** (1.62-2.74)	2.3*** (1.67-3.15)
Travel time in minutes to nearest hospital (Reference category 1st quintile – nearest hospital)				
2nd Quintile	0.8 (0.72-1)	0.8** (0.67-0.93)	0.9 (0.78-1.04)	0.9** (0.77-0.96)
3rd Quintile	0.8* (0.66-0.99)	0.8** (0.63-0.91)	0.9 (0.75-1.07)	0.8** (0.72-0.94)
4th Quintile	0.7** (0.6-0.92)	0.8* (0.66-0.95)	0.9 (0.72-1.03)	0.9 (0.74-1.03)
5th Quintile	0.7** (0.58-0.88)	0.7** (0.53-0.88)	0.9 (0.77-1.08)	0.8** (0.71-0.92)

[1] Adjusted effects after controlling for the effect of all the other explanatory variables.

What is already known on this subject

What is already known on this subject?

- Few countries have accurate data on hospital treated deliberate self-harm. Ireland is the only country in the world that has a national Registry for the population monitoring of hospital treated DSH.
- There is a paucity of large scale national studies examining how the geographic variation in hospital treated self-harm can be explained by area level risk factors.
- Previous research has shown that self-harm incidence is largely an urban phenomena, yet to date no study has established to what extent the high incidence of hospital treated self-harm in urban areas can be explained by the fact that hospitals tend to located in urban areas.

What this study adds?

- This is the first study of its kind to investigate how small area level variation in hospital treated self-harm incidence can be explained by proximity to hospital emergency departments, in addition to other area level risk factors.
- Positive linear associations between increased levels of self-harm and deprivation, social fragmentation and population density were found, with deprivation having the strongest effect.
- Although self-harm incidence was influenced by proximity to hospital services, deprivation was found to be the most important area level predictor of self-harm. Therefore, resources aimed at tackling self-harm, should prioritise these high risk deprived areas.

Chapter 6(b)

Mapping the incidence hospital treated deliberate self-harm in the five cities in the Republic of Ireland from 2009 to 2013 – A Short Report.

Introduction

The ecological relationship between self-harm and area level risk factors has previously been examined in Chapter 6(a) of this thesis. Therefore, the findings of this thesis have already demonstrated that self-harm incidence was influenced by proximity to hospital services, population density and social fragmentation; however, the strongest area-level predictor of self-harm was socioeconomic deprivation. This short report aims to build upon the findings of Chapter 6(a) by the application of mapping techniques to allow for the visualisation of pattern of hospital treated self-harm over the country from 2009 to 2013.

Worldwide, there is a dearth of research that has examined the spatial patterning of suicidal behaviour through the use of mapping techniques. To date much of the research in this area has focused on the spatial patterning of suicide in countries such as England and Wales, Australia, Canada and non-Western countries such as China and Taiwan, with less attention been given to examining the spatial distribution of self-harm. Examining the geographic variations in self-harm incidence can reveal local variations in risk and highlight local differences in mental healthcare needs and service provision.

Rates of suicide vary globally, ranging from zero to 30 per 100,000. Just like suicide, self-harm rates vary greatly between countries, for example low rates of self-harm have been reported for southern Europe and high rates in Northern Europe. Furthermore, self-harm have also been shown to exhibit distinct geographic variations within countries, with high rates being found in

city centres and urban areas and lower rates in rural areas. In Ireland, rates of self-harm have been shown to demonstrate distinct geographic variation. In Dublin and other city areas higher rates of self-harm have been found to be (224 and and 304 per 100,000 respectively) with lower rates being found in rural areas (139 per 100,000). These city rates are slightly lower than those reported for a Multicentre Centre study carried out in in three city cities in England.[154]

The examination of the spatial patterning of deliberate self-harm through mapping techniques has not been well researched as few countries have accurate data on self-harm. As mentioned in earlier chapters of the thesis, the Republic of Ireland is the only country in the world that has a National Registry of Deliberate Self-harm which provides reliable national-level data on the incidence of hospital treated self-harm.

Methods

Deliberate Self arm Data Population Data and Setting

Hospital treated deliberate self-harm data over a 5-year period (2009-2013) for persons aged 15 – 64 years were extracted from the National Registry of Deliberate Self Harm Ireland. Information regarding the Registry's case definition and case ascertainment have been previously outlined in a study by Perry et al.[23] The Registry geocodes the addresses recorded for every self-harm patient to a small geographical areas known as a district electoral division (DED). In total from 2009 to 2013 there were 45,138 persons aged 15 – 64 years presenting to hospital due to deliberate self-harm of which 42,707 were household residents. Only self-harm patients' with a household

residential address that was geocoded to small area level (DED) were included in the study.

There are 3,409 DEDs in the Republic of Ireland. The DED is the geographical unit of analysis in this study. There are five cities in the ROI, of which Dublin is the largest with a population of 527,612. The majority of the county of Dublin is urbanised, with almost 28% of population residing in this county. The four other cities (Cork, Limerick, Galway and Waterford) are made up of 171 DEDs and together account for 7% (298,597) of the population.

Population denominator data for each of the DED's by 5-year age and sex bands were obtained from the 2011 National Census files. As population estimates at DED geographical level were not available for non-census years, the 2011 Census population size for each DED was multiplied by 5 to get the 5-year population at risk.

Statistical Analysis

For each DED standardised incidence ratios (SIRs) for self-harm in persons aged 15-64 years over the 5 year study time period (2009-2013) were calculated. The SIR is the ratio of observed counts of self-harm cases in the study population to the expected count of self-harm cases in the general population. Expected self-harm cases were calculated by multiplying the national sex and age specific self-harm rates (in 5 year age bands) by the corresponding sex and age specific population in each DED. SIRs for males and females aged 15-39 and 40-64 years were also calculated.

To overcome the issue of unreliability in SIRs due to small numbers of self-harm cases and small population sizes, Bayesian hierarchical models were used to calculate smoothed SIRs for each DED before mapping. Bayesian hierarchical models were also carried out to examine the effect on the smoothed SIR after controlling for the area socioeconomic deprivation. Bayesian hierarchical models were based on a Poisson assumption, and allowed for both (1) global between area variability (non-structural variability) and (2) local variability due to spatial autocorrelation (structural variability). Therefore, the smoothed SIR is a weighted average of the observed SIR, the national mean, and rates of neighbouring DEDs.[155] Neighbouring DEDs were defined as DEDs that shared a common boundary. Bayesian hierarchical models were fitted using the Markov chain Monte Carlo methods with WinBUGS version 1.4 software. Separate Bayesian models were carried out for each age and sex group. The posterior mean of each DED's distribution of rate ratio estimates was mapped.

To test for spatial autocorrelation Moran's I statistic was calculated using the software package Geo Da. Spatial autocorrelation means a similarity exists between attributes of neighbouring areas, this implies that geographically close areas are more similar than areas that a geographically far apart or distant areas. In this analysis neighbouring areas were defined as areas that share a common border, i.e. first order adjacency. Moran's I statistic can be a positive value, a negative value or have a zero value, the maximum value for Moran's I is +1 and the minimum value is -1. Positive spatial autocorrelation occurs when Moran's I is close to +1 and indicates that neighbouring areas have similar attributes. Negative spatial autocorrelation

occurs when Moran's I is near to -1 and indicates that neighbouring areas have dissimilar attributes and a value of zero for Moran's I statistic indicates no autocorrelation

Results

Table 6.6 displays the Moran's I statistics by the different age and sex groups. There was evidence of spatial autocorrelation for both genders combined (Moran's I =0.32, P<0.001), males (Moran's I =0.30, P<0.001) and females (Moran's I =0.25, P<0.001). There was also evidence of spatial autocorrelation for both genders when broken down by age groups. Moran's I was stronger in the younger 15 to 39 year age group for both males (Moran's I =0.27, P<0.001) and females (Moran's I =0.20, P<0.001).

Table 6.6 Moran's I statistics by the different age and sex groups, 2009 to 2013

	Morans I p-values
Persons	
15-64 years	0.32 (p=0.001)
15-39 years	0.28 (p=0.001)
40-64 years	0.17 (p=0.001)
Males	
15-64 years	0.30 (p=0.001)
15-39 years	0.27 (p=0.001)
40-64 years	0.22 (p=0.001)
Females	
15-64 years	0.25 (p=0.001)
15-39 years	0.20 (p=0.001)
40-64 years	0.18 (p=0.001)

Maps of hospital treated self-harm

In Figure 6.1 maps of smoothed SIRs from the Bayesian hierarchical models are presented for the period 2009 – 2013 for all persons aged 15-64 years. As patterns in small scale national maps are hard to interpret and distinguish, five insets showing the five most populated cities in Ireland (Dublin, Cork, Limerick, Galway and Waterford) are presented. In Figure 5.2 maps presenting the smoothed residual SIRs after adjustment for socioeconomic deprivation and social fragmentation for all persons aged 15-64 years are presented.

The series of maps in Figure 6.1 demonstrated the high rates of hospital treated deliberate self-harm among persons aged 15-64 years across the DED's within the five cities, (illustrated by areas shaded red) with lower rates being found in the peripheral areas outside and surrounding the cities (illustrated by areas shaded blue). The geographic distribution of hospital treated deliberate self-harm varied greatly across the DED's of the five cities. In Galway city, smoothed SIR's varied from 0.58 to 2.45, in Dublin city smoothed SIR's varied from 0.18 to 3.12, in Waterford city smoothed SIR's varied from 0.81 to 4.03, in Cork city smoothed SIR's varied from 0.39 to 6.06, and in Limerick city the greatest variation was found, with smoothed SIR's ranging from 0.41 to 7.73. In Limerick city the map is dominated by high rates (shaded red), with the vast majority of areas (86.8%) having rates of deliberate self-harm that were higher than the national rate, likewise, in Cork City, the map is dominated by high rates with 73.0% of areas having rates higher than the national rate, also in Waterford City 67.6% of areas had rates higher than the national rate, and in Galway City 50% of areas had

rates higher than the national rate. In Dublin City only a third of areas had rates higher than the national rate (32.9%).

Comparing Figure 6.1 with residual map demonstrates the extent to which patterns seen in Figure 6.2 can be explained by the area level socioeconomic deprivation. For each of the five cities, striking reductions in the rates of self-harm can be seen, which indicates the increased rate of self-harm in city areas can largely be explained by degree of socioeconomic deprivation in these areas.

Figure 6.1 Smoothed standardised incidence ratios (SIRs) for self-harm in persons aged 15-64 years in the five cities across the Republic of Ireland, 2009-2013

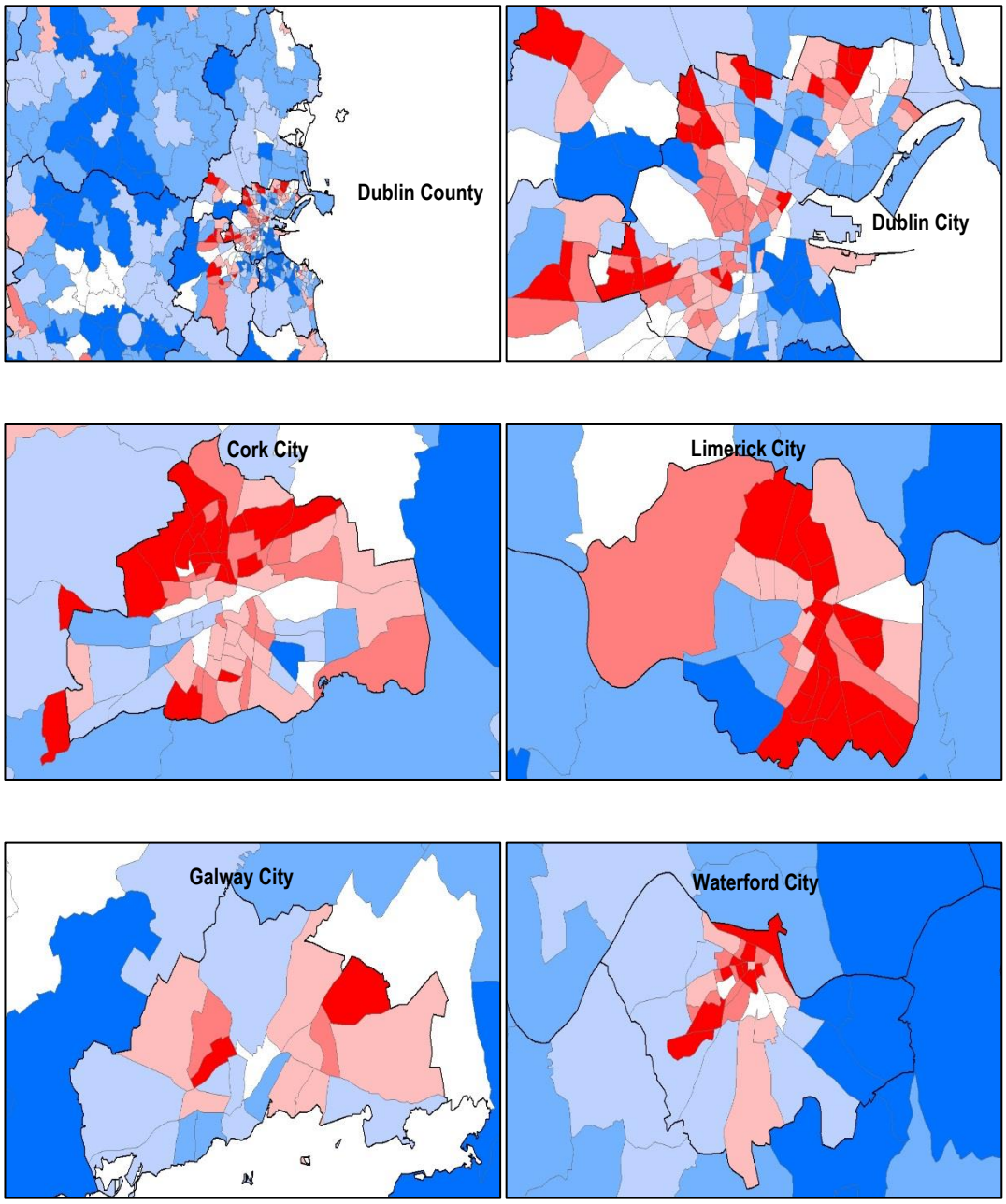
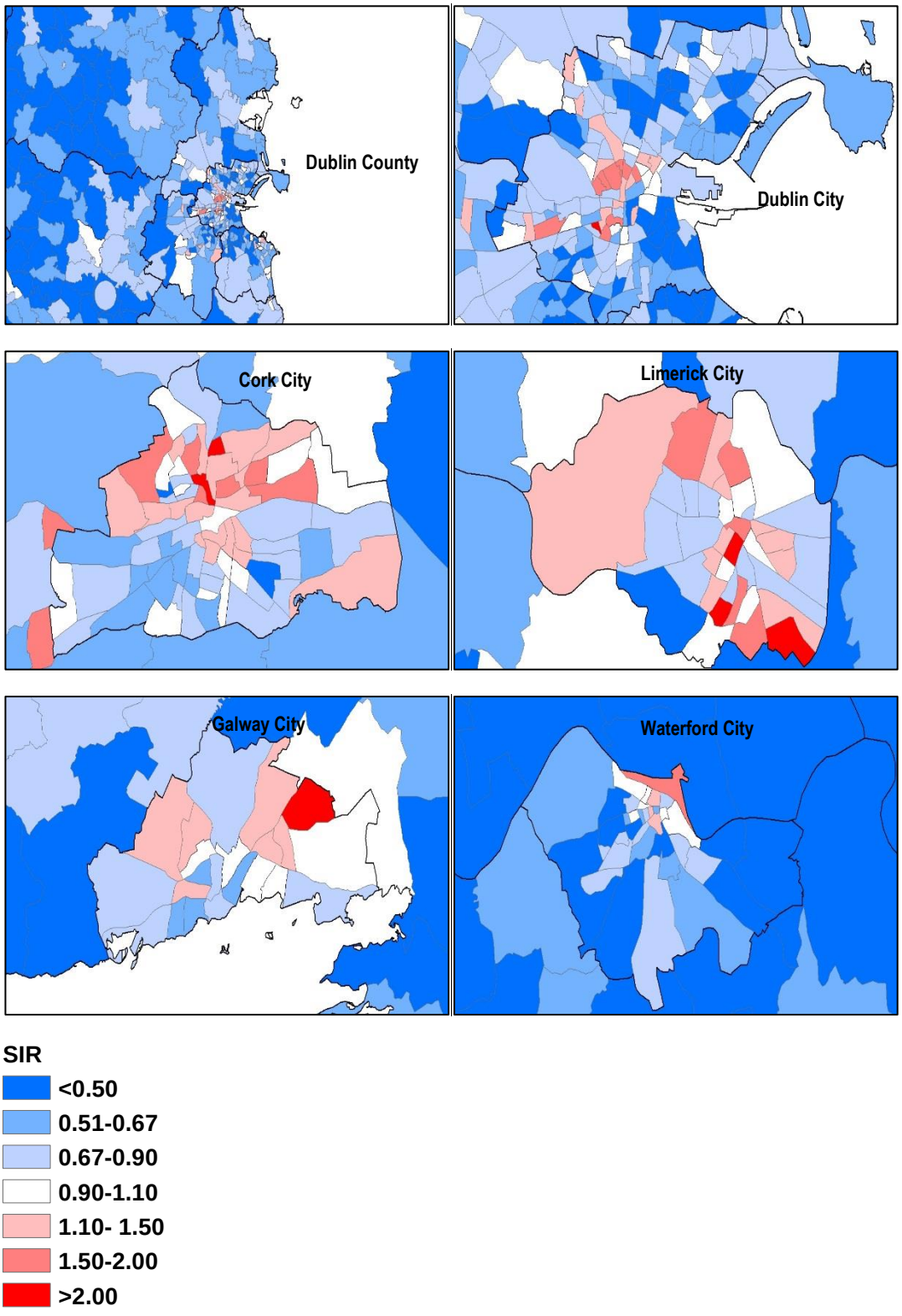


Figure 6.2 Residual (adjusted for socioeconomic deprivation) smoothed standardised incidence ratios (SIRs) for self-harm in persons aged 15-64 years in the five cities across the Republic of Ireland, 2009-2013



Chapter 7

The area level association between suicide, deprivation, social fragmentation and population density in the Republic of Ireland – a national study

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Abstract

Purpose:

Numerous studies have examined the ecological relationship between suicide and area level determinants such as socioeconomic deprivation and social fragmentation. In Ireland, there is considerable geographic variation in the rates of suicide. However, there is a dearth of Irish studies investigating the geographic variability of suicide.

Methods:

The Irish Central Statistics Office (CSO) provided data relating to all deaths by suicide and deaths of undetermined intent that occurred from 2009 to 2011. Negative binomial regression was used to examine the relationship between area level suicide rates and measures of socioeconomic deprivation, social fragmentation and population density that were taken from the 2011 National Census.

Results:

Overall socioeconomic deprivation had the strongest independent effect on small-area rates of suicide, with the most deprived areas showing the greatest risk of suicide (risk ratio=2.1; 95% CI 1.70-2.52). Low population density (rurality) was associated with an increased risk suicide in males across both age groups and among females in the older 40-64 year age group. Conversely, a weak association between high population density (urbanicity) and increased suicide risk was found among females in the 15-39 year age group. Associations with social fragmentation only became apparent in the sub group analysis. Social fragmentation was associated with

an elevated risk of suicide in the older 40-64 age group, with this effect being most pronounced among females.

Conclusion:

The findings of this study demonstrate marked geographical inequalities in the distribution of suicide in Ireland and highlight the importance of targeting suicide prevention resources in the most deprived areas.

Introduction

Suicide is a major public health problem both globally and nationally in Ireland. Ireland has the 5th highest youth suicide rate in Europe. Identifying the individual level risk factors for suicide is an integral part of any effective suicide prevention strategy, but in addition to this, it has been suggested that the social context in which an individual lives needs to be considered also.[156, 157] For example, area of residence may negatively influence levels of social support or the likelihood of developing a mental illness both of which increase the risk of suicide.[158] Previous research has shown that a number of area level determinants are associated with the geographic distribution of suicide; these factors include socioeconomic deprivation and social fragmentation.[104, 127] Although a considerable number of studies have examined the association between suicide and these area level risk factors, the findings have been somewhat divergent. A systematic review of 86 studies involving 221 separate analyses found that the overall results were mixed but tended toward showing that increased socioeconomic deprivation was associated with an increased risk of suicide.[129] However, certain studies have shown no association between area level socioeconomic deprivation and suicide. [130-133] While other studies have shown that other area level factors such as social fragmentation have a stronger association with suicide risk than socioeconomic deprivation.[134 127, 128, 135]

In Ireland, there is considerable geographic variation in the rates of suicide. However, there is a dearth of studies investigating the spatial disparities of suicide in the Republic of Ireland. One of the first studies to explore this phenomenon looked at rates of suicide in Dublin City and County over a 10

year period from 1954 to 1963. It was found that the highest rates of suicide occurred in central parts of Dublin city which the authors concluded were "central disorganised areas with large numbers of people living in social isolation".[9] Another study found that from 1980 to 1990 the Irish male suicide rate increased by 50% in rural areas while there was no increase in the male suicide rate in urban areas.[141] Other research also found this persistence of higher rates of suicide in males from rural areas than males from urban areas .[142] Connolly and Lester examined the correlation between suicide and socio-demographic determinants (such as GDP, unemployment rate, expenditure, marriage rate, crime rate) at county level and found no association between suicide risk and sociodemographic factors except for crime.[143] However to date, no study in the Republic of Ireland has examined the association between suicide risk and area level determinants at a more meaningful small scale geography level.

The aim of this study is to examine the small area level association between suicide and the following three area level factors, socioeconomic deprivation, social fragmentation and population density.

Methods

Suicide Data

The Irish Central Statistics Office (CSO) provided data relating to all deaths by suicide and deaths of undetermined intent (respectively, codes X60– X84 and Y10–Y34 of the Tenth Revision of the International Classification of Diseases, Injuries and Causes of Death (ICD-10) that occurred from 2009 to 2011. For the purpose of this study, deaths of undetermined intent (Y10-Y34)

were combined with suicide deaths (X60-X84) (as is standard practice in suicide research) and from herewith shall be referred to as suicide deaths. All addresses were geocoded to small geographical areas called district electoral divisions (DEDs). In the Republic of Ireland there are a total of 3,409 DEDs. The geographical unit of analysis in this study is the DED. According to the 2011 Census, DEDs had a mean population of 1,346 and ranged in population size from 73 to 36,057. From 2009 to 2011, the CSO recorded that were 1736 deaths dues to suicide and undetermined intent in persons aged 15 to 64 years. As there were a limited number of suicide cases in children and older adults the study population was restricted to the 15–64-year-old age group. Seeking to explain the small area level variation in these suicide rates was deemed to be of limited value.

In total, 5% (82/1736) of deaths were excluded from this study for the following reasons; 1% of deaths had a non-household residential address, 1% of deaths had a residential address outside of the Republic of Ireland and 3% of deaths had an address that was not detailed or not specific enough to assign to an individual DED. In total, our study sample consisted of 1654 deaths due to suicide/undetermined deaths.

Socioeconomic Deprivation

An Irish deprivation index, called The Pobal HP Deprivation Index 2011 was used in this study.[103] The HP Deprivation Index is based on a prior conceptualisation of the underlying dimensions of socioeconomic deprivation and uses confirmatory factor analysis to estimate deprivation scores. The HP Index draws on ten indicators taken from the 2011 Census to express a combination of three dimensions of affluence and socioeconomic deprivation:

(a) Demographic Profile, (b) Social Class Composition and (c) Labour Market Situation. The 10 census indicators include; (1) % change in population over the previous five years; (2) % of persons aged under 15 or over 64 years of age; (3) % of persons with a primary school education only; (4) % of persons with a third-level education; (5) mean number of persons per room; (6) % of households headed by professionals or managerial and technical employees; (7) % of households headed by semiskilled or unskilled manual workers; (8) % of households with children aged under 15 years and headed by a single parent; (9) male unemployment rate and (10) female unemployment rate. It has been argued that widely used socioeconomic deprivation indices such as the Index of Multiple Deprivation (IMD) and the Townsend Score have an urban bias as they were designed to measure urban socioeconomic deprivation, therefore such indices may fail to capture rural socioeconomic deprivation.[129] As Ireland has a considerable rural population, it is particularly important for a socioeconomic deprivation index to be capable of capturing urban and rural socioeconomic deprivation. The authors of the HP Deprivation Index state that demographic decline which is measured by emigration (the percentage change in population over 5 years), the concentration of economically dependent individuals (the percentage of population aged under 16 or over 65 years) as well as those with lower levels of education (percentage of population with primary school education) is the most representative measure of rural socioeconomic deprivation. DEDs were divided into quintiles based on their HP deprivation score (1 = the least deprived areas, 5 = the most deprived areas).

Social Fragmentation

The social fragmentation score used in this study was based on Congdon's anomie score.[104] This anomie score was developed by Congdon in an attempt to empirically test Durkheim's theory of "anomie". Durkheim hypothesised that the lack of social integration was associated with increased suicide risk. Congdon's research showed that "anomie" or "community fragmentation" was a strong predictor of suicide rates in local authority regions in London. Originally named an "anomie score" by Congdon this measure was renamed "social fragmentation score" by Whitley and colleagues.[127] Although Congdon's fragmentation score has been extensively used in other area level studies of suicide, the causal pathway between suicide and fragmentation is not well understood. Furthermore, the transferability of this fragmentation score to other countries is not known.

The social fragmentation score was calculated by summing the z scores of four variables that were taken from 2011 Irish Census. These variables include, the percentage of persons who have moved in the last year, the percentage of unmarried persons, the percentage of single person households and the percentage of persons in private rented accommodation. DEDs were divided into quintiles based on their fragmentation score (1 = the least fragmented areas, 5 = the most fragmented areas).

Population Density - Area Type

The classification of an area type was dependent upon the population density of the small area (DED). DEDs were divided into quintiles based on their population density (1 = the most rural areas, 5 = the most urban areas).

Incidence rates

The pooled 2009 to 2011 incidence rate per 100 000 population for suicide and undetermined deaths was calculated for the total, male and female population (and for age and sex subgroups i.e. males and females aged 15–39 years and 40–64 years). Population data was based on the 2011 National Census. Poisson regression assessed the effect of gender in relation to the incidence of suicide and undetermined deaths. Effects were reported as incidence rate ratios (IRRs) with 95% confidence intervals (CIs)

Statistical Analyses

All statistical analyses have been carried out using the STATA statistical software version 12.[105] Negative binomial regression was used to investigate the relationship between suicide and socioeconomic deprivation, population density and social fragmentation. The associations with each of the area level explanatory variables before and after controlling for the effect of all the other variables were investigated. Wald tests were used to determine the effect modification by age and gender for each of the 3 explanatory variables. Negative binomial models were also estimated separately for males and females aged 15-39 years and 40-64 years. In each analysis, the lowest quintile (quintile 1) was taken as the reference group. In addition, each of the models was also adjusted for spatial autocorrelation by indicating that the DEDs were clustered by county. Results were expressed as incidence rate ratios with 95% confidence intervals.

Results

Incidence rates by age and gender

From 2009 to 2011, there were 1464 suicide deaths and 190 deaths due to undetermined intent, giving a combined total of 1654 (Table 7.1). The pooled 2009-2011 all person rate per 100 000 for suicide, undetermined deaths and both suicide and undetermined deaths combined were, 16, 2 and 18 respectively. Rates of suicide and undetermined deaths combined were 3.9 times higher in males than females, with rates being highest among males in the 15-39 year age group.

Effects of socioeconomic deprivation, social fragmentation and population density on the incidence of suicide

In Table 7.2, the results from both the univariable and multivariable negative binomial regression analysis on all persons aged 15 to 64 years are presented. Rates of suicide were found to be most elevated in the upper quintile for socioeconomic deprivation and this association remaining largely unchanged after adjustment for social fragmentation and population density. Social fragmentation was associated with an increased risk of suicide; however the association was weak. Increased levels of population density were associated with a lower risk of suicide. The relationship between population density and suicide remained almost unchanged after adjustment for socioeconomic deprivation and social fragmentation. Overall, the strongest association was found between socioeconomic deprivation and small area suicide rates.

Effects of socioeconomic deprivation, social fragmentation and population density on the incidence of suicide stratified by age and gender

Effect modification by age and gender was investigated for each of the three area level factors and it was found that the strength of the association between suicide and the various area level factors differed between the younger and older age groups and between males and females. In Table 7.3, the effects of the area level factors on DED suicide rates stratified by age and gender are shown. The association between increasing levels of socioeconomic deprivation and increasing levels of suicide was evident for men and women. For both males and females, the effect of socioeconomic deprivation was greatest in the 15 to 39 year age group. Females in this age group showed the most marked effects, with rates of suicide in the most deprived areas being over 3 times greater than rates in the least deprived areas. However, it must be noted that overall, no significant interaction between either age and socioeconomic deprivation (χ^2=4.7, P=0.32) or gender and socioeconomic deprivation (χ^2=2.96, P=0.57) were found. Although no strong association between suicide and social fragmentation was found when all ages and both genders were combined, there was evidence of effect modification by age (χ^2=12.3, P<0.05) and gender (χ^2=35.9, P<0.01). This indicated that the strength of the association varied in different age/sex bands. Social fragmentation was associated with a greater risk of suicide in the older 40-64 age groups for both genders. This effect was most pronounced among females in this older age group, with rates of suicide in the most fragmented areas being over 2.4 times greater

than rates in the least fragmented areas. It appears that the magnitude of the association between suicide and social fragmentation may be stronger than the association with socioeconomic deprivation for females in the older 39-64 year age group. Amongst the younger 15-39 age group in both males and females, increasing levels of social fragmentation was associated with a reduced risk of suicide, although this effect did not reach conventional levels of statistical significance The effect of increasing levels of population density on suicide rates differed between males and females (χ^2=17.9, P<0.001). Among males, increasing levels of population density was associated with decreased levels of suicide. This relationship was most pronounced in males aged 40-64 years, with suicide rates in most densely populated areas (urban areas) being over 50% lower than suicide rates in the least densely populated areas (rural areas). For females, the direction of the association was less clear. In females aged 40 to 64 years, low population density (rurality) was associated with increased levels of suicide, whereas in the 15 to 39 year olds, high population desnity (urbanicity) was associated with increased suicide rates, although it must be noted that neither of these associations for females was statistically significant. No significant interaction between age and population density was found (χ^2=1.3, P=0.85).

Discussion

Main Findings

This study is the first to demonstrate marked geographical inequalities in the distribution of suicide in the Republic of Ireland. Socioeconomic deprivation rather than social fragmentation or population density was found to have the

strongest independent association with area level suicide rates when all ages and both genders were combined. Furthermore, the association between socioeconomic deprivation and suicide held across genders, with this effect being especially marked in the female 15-39 age group. Associations between suicide and social fragmentation only became apparent in the sub-group analyses where it was shown that social fragmentation was associated with an elevated risk of suicide for males and females in the 40-64 year age group. Moreover, this effect was most pronounced among females in this age group. No association between increasing levels of social fragmentation and suicide risk was found in the 15-39 age groups for either gender. Furthermore, the effect between population density and suicide was found to differ between males and females. In males, low levels of population density (rurality) were found to be independently associated with increased area level suicide risks. However, in females the association with population density was weaker and less clear. Low levels of population density (rurality) were associated with an increased suicide risk in the female 40-64 age group whereas high levels of population density (urbanicity) were associated with an increased risk in the female 15-39 age group.

In this study we found that when all ages and both genders were combined, socioeconomic deprivation was the stronger area level predictor of suicide. Research carried out in the Republic of Ireland has demonstrated that socioeconomic deprivation was also the strongest area level predictor of hospital treated deliberate self-harm.[115, 139] Previous studies have shown mixed findings in establishing whether social fragmentation or socioeconomic deprivation was more important in determining area level suicide rates.

Some studies have found that socioeconomic deprivation was more strongly associated with area level rates of suicide than social fragmentation,[130] other studies have found that social fragmentation had a stronger influence than socioeconomic deprivation, [127, 128, 134, 135] and some studies have found no association between increased levels of social fragmentation and suicide.[159] In this study, the relationship with social fragmentation only became apparent when area level effects were analysed by age group. Increasing levels of social fragmentation were associated with an increased risk of suicide in the older 40-64 year age group for both males and females, and conversely increased levels of social fragmentation were weakly associated with a reduced suicide rate in the 15-39 age group. It must be noted that both of these associations only reached statistical significance in the most fragmented areas (quintile 5). This finding is contrary to previous research that showed the relationship with social fragmentation and suicide was consistent across age groups, [158] or stronger in the younger age groups.[134] One of the reasons that we may not have been able to replicate previous research findings between increased fragmentation and suicide risk is that socioeconomic deprivation may be a more important area level predictor of suicide than social fragmentation in younger populations in this study. Or alternatively, it may be that it was not possible to demonstrate an association with increased levels of social fragmentation and suicide risk because the measures included in Congdon's index may not be capturing the concept of social integration in younger populations. For example, it is plausible the indicators contained within Congdon's index may just be capturing areas with high levels of young professionals who have low suicide rates but inflate the

area's level of social fragmentation by being unmarried, living alone, living in rented accommodation and moving frequently. A previous Irish study has also shown that increasing levels of social fragmentation was associated with reduced area level rates of deliberate self-harm among younger men and women in Dublin.[139] Looking at both genders combined, decreased levels of population density was associated with an increased risk of suicide, with suicide rates in the most densely populated areas being 30% lower than rates in the least populated areas. However, when looking at this association by gender, increasing levels of population density was associated with a reduction in suicide risk in males but an elevated risk in females (only in 15-39 year age group), it must be noted that this association in females did not reach statistical significance. The study's finding that rurality is associated with an elevated risk of suicide in males is consistent with previous research carried out in Australia,[160] England and Wales,[161] Finland,[162] the United States [163] and Scotland.[164] Our finding that urbanicity was associated with an increased risk of suicide in females is in line with studies carried out in Denmark.[165, 166] It has been postulated, that the reason urbancity is associated with an elevated suicide risk in females but not males may be attributed to certain features of living in an urban setting affecting males and females in a different way. For example better job opportunities may be more likely to benefit men, whereas females may be more vulnerable in a competitive urban environment than males.[165] Not all studies have shown a significant association between area type and suicide risk for example a study in study in Northern Ireland found no association between area type and suicide.[159] Furthermore, previous research in Ireland has

shown that rates of hospital treated self-harm were lowest in rural areas that are located far from hospital services. [115] This suggests under recognition of self-harm in rural and non-urban areas and may be a factor in the high suicide rates in these areas.

Strengths

This is, to our knowledge the first ecological study to investigate the small area level association between socioeconomic deprivation, social fragmentation and population density in the Republic of Ireland, and the national perspective of this study is one of its strengths. We carried out all analyses using data related to officially classified suicides plus undetermined deaths in order to show that the findings were robust to the effects of misclassification. We stratified by age and gender and examined the findings for effect modification by age and gender. It has been suggested in the literature that the use of socioeconomic deprivation indices may fail to identify rural socioeconomic deprivation.[151] The HP Pobal Deprivation Index (as used in this study) is unique compared to other European socioeconomic deprivation indices, as it includes a specific measure of rural socioeconomic deprivation (demographic decline), which the authors of this socioeconomic deprivation index argue is the most representative measure of rural socioeconomic deprivation.

Limitations

There are a number of limitations in our analysis. Firstly, it has been found that results of ecological studies can greatly depend on the scale of the geographical unit and that ecological studies are more informative when conducted on small scale areas.[144] Although our analysis was based on

3,409 small scale geographical units (DEDs), DEDs are not uniform in size. DED boundaries have not changed in many years, and because of Ireland's increasing urbanisation and rapidly changing settlement patterns, these DEDs can vary greatly in population size and therefore may be not homogenous in terms of their characteristics. However it must be noted that only 5% of DEDs have a population in excess of 5000. Secondly, there is no universally agreed definition of what rural and urban is. In this study we have used population density as a proxy measure of the urban-rural character of an area, similar ecological studies carried out elsewhere have also used this definition. [159] We acknowledge that this is just one of the many techniques available for defining rural and that the use of different measures may result in differences in the classification of an area.[167] Thirdly, the cross national transferability of Congdon's social fragmentation index has been questioned in previous research.[168] It is possible that Congdon's measure of social fragmentation may not be transferable to an Irish setting as Congdon's index was developed to measure social fragmentation in the urban setting of London and therefore may not work so well in Ireland with its relatively large rural population. Furthermore, it has been suggested that Congdon's Index should be updated to reflect social trends such as the increase in private rented accommodation and co-habitation.[169] Fourthly, it has been argued that there is no sound conceptual base underpinning the choice of variables included in a socioeconomic deprivation index. The selection of variables is often influenced by the availability of indicators from the National Census, as Census data is often the most objective and uniform data available.[170] Also there is no universally agreed methodology in how the socioeconomic

deprivation indicators can be combined to produce a single deprivation score, some deprivation indices use simple additive techniques, some use weights for each indicator and others use multivariate techniques.[171] Therefore, there is a need for deprivation indices to follow uniform methodological principles to enable comparability across countries. Fifthly, the accuracy in the geocoding of the suicide address data may not be optimal as Ireland currently lacks adequate geographical information systems. Lastly, as this research was based on aggregated area level data, it was not possible to determine to what extent the effects of individual level risk factors for suicide explain through confounding the effects of area level characteristics. There is a need for future studies to apply multilevel modelling techniques to establish the effects of an area independently of the characteristics of the individual's living there.[172]

The findings from this study show marked geographic inequalities in the distribution of suicide in Ireland, with the risk of suicide being greatest in the most deprived areas and in the most rural areas, there was also some evidence to suggest an elevated risk of suicide in the most socially fragmented areas especially among older age groups. Research in Ireland has shown that individuals are most likely to contact a General Practitioner (GP) when experiencing mental health issues than any other specialist services.[173] Yet, in Ireland it has been argued that access to primary health care is inequitable in terms of geographical access with deprived rural areas being the most underserved by GP services.[174] However, improving access to healthcare services is just one of the factors involved in tackling area level inequalities in suicide. In the context of addressing area inequalities in

suicide, community based suicide prevention strategies should be prioritised in the most deprived areas. Previous research in Ireland has also recommended prioritising suicide prevention resources in deprived areas,[115, 139] as these areas were found to have high incidences of deliberate self-harm; it is widely recognised that deliberate self-harm is one of the strongest risk factor for suicide. Future research should be carried out to examine the spatial pattern of suicide and its association with area level determinants by the use of mapping techniques. This would provide a greater understanding in the local geography of suicide,[135] and enable both the investigation of the residual variability after adjusting for area level characteristics and the examination of possible interaction effects in contextual factors (such as the differential effects of social fragmentation in rural and urban areas). Geographical appropriate methods such as Bayesian hierarchical models should be used to tackle the issue with uncertainty in estimating small area suicide rates and to allow for adjustment for spatial autocorrelation.[175] To date only a limited number of such studies have been carried out. [135, 175-178]

Lastly, as the time frame of this study is during the post economic recession period, it is plausible that the nature of the relationship between suicide and the area level determinants may have differed had it been examined in the pre-recession years. Recent area level analysis on suicide and undetermined deaths that occurred in the pre-recession years (2006-2007) in persons aged 15-64 years has been carried out (see Appendix 3. Supplementary Table 7.4 for details). The results showed that the area level associations appeared to be broadly similar in the pre-recession and post-recession years with a small indication of a stronger effect of socioeconomic deprivation in the pre-

recession period and slightly lower rates of suicide in the most densely populated areas in post-recession period.

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Authors' contributions

IBOF, PC and IJP conceived and designed the study. IBOF wrote the initial and subsequent drafts of the manuscripts and PC and IJP revised the manuscript critically for important intellectual content. IBOF carried out the data analysis. All authors have seen and approved the final version of the report.

Conflicts of interest

None declared.

Table 7.1 Age and gender distributions of the study population

	Persons		Males		Females			
	N	Rate	N	Rate	N	Rate	IRR[1]	95% CI
Suicides								
15 to 39 years	781	15	644	25	137	5	4.6	3.83-5.55
40 to 64 years	683	17	555	27	128	6	4.3	3.57-5.25
All ages 15 to 64 years	1464	16	1199	26	265	6	4.5	3.92-5.11
Undetermined deaths								
15-39 years	96	2	70	3	26	1	2.6	1.68-4.14
40 to 64 years	94	2	52	3	42	2	1.2	0.82-1.86
All ages 15 to 64 years	190	2	122	3	68	1	1.8	1.32-2.39
Combined suicide and undetermined deaths								
15 to 39 years	877	17	714	28	163	6	4.3	3.62-5.09
40 to 64 years	777	19	607	29	170	8	3.6	3.01-4.23
All ages 15 to 64 years	1654	18	1321	28	333	7	3.9	3.48-4.42
1 Incidence Rate Ratio (IRR) of suicide in males compared to females								

Table 7.2 Associations between suicide and socioeconomic deprivation, social fragmentation and population density in persons aged 15-64 years

	Unadjusted IRR[1] 95% CI				Adjusted IRR[2] 95% CI			
	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Socioeconomic Deprivation	1.3 1.15-1.53	1.5 1.29-1.82	1.7 1.4-2.02	2.1 1.74-2.53	1.3 1.11-1.52	1.5 1.26-1.8	1.6 1.35-2	2.1 1.70-2.52
Social Fragmentation	1.1 0.85-1.47	1.2 0.92-1.52	1.1 0.87-1.38	1.2 0.92-1.59	1.0 0.81-1.37	1.1 0.9-1.42	1.1 0.87-1.3	1.2 0.98-1.54
Population density	0.8 0.63-1.14	0.8 0.64-0.98	0.8 0.63-0.9	0.7 0.57-0.95	0.9 0.63-1.17	0.8 0.66-1.05	0.8 0.63-0.95	0.7 0.55-0.98

[1]Incidence Rate Ratios (IRRs) - Unadjusted effects of each area level variables before controlling for the effect of the other explanatory variables.

[2] Incidence Rate Ratios (IRRs) - Adjusted effects after controlling for the effect of all the other explanatory variables including age and gender.

Table 7.3 Associations between suicide and socioeconomic deprivation, social fragmentation and population density in persons stratified by age and gender

Explanatory Variable	Males 15-64 yr olds IRR[1] (95%CI)	Males 15-39 yr olds IRR[1] (95%CI)	Males 40-64 yr olds IRR[1] (95%CI)	Females 15-64 yr olds IRR[1] (95%CI)	Females 15-39 yr olds IRR[1] (95%CI)	Females 40-64 yr olds IRR[1] (95%CI)
Socioeconomic Deprivation						
2nd Quintile	1.3 1.13-1.57	1.2 0.96-1.61	1.4 1.19-1.67	1.2 0.8-1.67	1.2 0.68-2.09	1.1 0.69-1.74
3rd Quintile	1.5 1.27-1.7	1.6 1.21-2.06	1.3 1.11-1.6	1.6 1.05-2.54	1.6 0.94-2.81	1.6 0.96-2.6
4th Quintile	1.7 1.4-2.01	1.9 1.45-2.42	1.5 1.17-1.85	1.5 0.98-2.29	1.9 1.01-3.51	1.2 0.67-2.09
5th Quintile	2.1 1.67-2.56	2.3 1.68-3.11	1.8 1.43-2.32	2.1 1.56-2.74	3.1 1.98-4.71	1.4 0.99-1.88
Social Fragmentation						
2nd Quintile	1.2 0.91-1.46	0.9 0.66-1.33	1.4 1.06-1.91	0.6 0.35-1.17	0.3 0.14-0.79	1.1 0.5-2.62
3rd Quintile	1.2 0.97-1.49	1.0 0.67-1.45	1.5 1.14-1.89	0.8 0.5-1.42	0.7 0.36-1.25	1.1 0.52-2.23
4th Quintile	1.1 0.9-1.33	0.9 0.6-1.28	1.4 0.98-1.87	0.9 0.6-1.43	0.5 0.23-0.9	1.8 0.86-3.71
5th Quintile	1.2 0.96-1.46	0.8 0.56-1.19	1.8 1.28-2.44	1.3 0.84-2.11	0.7 0.4-1.36	2.4 1.12-5.23
Population density						
2nd Quintile	0.8 0.58-1.2	0.9 0.58-1.3	0.8 0.52-1.27	1.0 0.58-1.77	1.7 0.38-7.74	0.8 0.38-1.62
3rd Quintile	0.8 0.65-1.06	0.9 0.59-1.24	0.8 0.56-1.15	0.8 0.42-1.64	1.7 0.35-8.36	0.5 0.24-1.21
4th Quintile	0.7 0.58-0.93	0.7 0.52-1.08	0.7 0.49-1.08	1.0 0.6-1.76	1.8 0.42-7.57	0.8 0.47-1.28
5th Quintile	0.7 0.5-0.91	0.8 0.55-1.24	0.5 0.37-0.81	1.1 0.6-1.98	2.1 0.46-9.8	0.7 0.42-1.31

[1] Incidence rate ratios (IRRs) -Adjusted effect after controlling for the effect of all the other explanatory variables.

Chapter 8
Discussion

Discussion

The main aim of this thesis was to contribute to the current international evidence base by establishing the risk of suicide and deaths due other external causes among individuals who present to hospital following self-harm in the Republic of Ireland. The secondary aim was to examine the influence of area level determinants on the incidence of hospital treated self-harm and suicide. Additionally, the geography of hospital treated self-harm was further described and examined by the application of mapping techniques to allow for the visual examination of small area level variation in self-harm across the five main cities in the Republic of Ireland. Therefore, this chapter will firstly outline the main findings of this thesis. Secondly, the main strengths and limitations of this work are highlighted. Thirdly, the clinical and public implications of the findings are outlined. Lastly, recommendations for policy and future research are discussed.

Main Findings - Risk of suicide and death from other external causes following self-harm

During the study follow-up, 437 patients died from external causes. The average 1-year cumulative incidence for suicide, non-suicide external cause mortality and all external causes combined were 0.8% (95%CI 0.7-1.0), 0.5% (95%CI 0.4-0.6) and 1.3% (95%CI 1.2-1.5), respectively. The risk of suicide was 46 times (95% CI 39-54) greater in self-harm population compared to the general population and relative risks were higher in females than males suicide (females; IRR 63 95% CI 46-87, males; IRR 43 95% CI 35-51). Risk of other external cause mortality was also greater in the self-harm population compared to the general population (females; IRR 30 95% CI 21-44, males;

IRR 20 95% CI 15-25). While the relative risk of death were higher in the female self-harm population when compared to the female general population, the absolute risk of death (for both suicide and non-suicide external cause) was found to be higher in males than females. Older age and male gender were associated with an elevated risk of death. Risk of death from suicide (not non-suicide external causes) varied depending on method of self-harm. Compared with overdose alone attempted hanging had the greatest risk of suicide, particularly in females (females; HR 6.8 95% CI 3-15.7, males; HR 2.6 95% CI 1.6-4.3), major self-cutting was also associated with a 2-fold increased risk (HR 2.1 95% CI 1.3-3.5). Self-harm repetition was found to be a strong predictor of subsequent death. Compared to individuals with no repeat acts, persons with a history of three or more repeat acts had a 3.7 fold increased risk (HR 3.7, 95% CI 2.5-5.7) of all external cause mortality with this association being most marked in females (females; HR 6.7, 95% CI 3.8-12.0 and males; HR 2.3, 95% CI 1.2-4.4).

Main Findings – The influence of area level determinants on the incidence of deliberate self-harm and mapping the incidence of self-harm in five cities in Ireland

Socioeconomic deprivation, social fragmentation and population density had a positive linear association with self-harm, with socioeconomic deprivation having the strongest independent effect. Furthermore, self-harm incidence was found to be elevated in areas that had shorter journey times to hospital. However, while this association became attenuated after controlling for other area-level factors it still remained statistically significant. Previous studies have also shown that socioeconomic deprivation was the strongest

independent area level predictor of self-harm.[116, 137, 147] Socioeconomic deprivation was also found to have the greatest effect in the younger age group than the older age group, this is also in line with previous research.[130] We found that the effect of fragmentation was modified by age with stronger effects been found in the older age groups and this finding is in line with previous research.[116] However, the relationship between self-harm and fragmentation was weakened after adjustment for the other area level explanatory variables, and again this finding is in agreement with previous studies.[116, 137] Moreover, the linear association between increasing incidence of self-harm and increasing levels of population density are also consistent with previous studies carried in the other countries such as the United Kingdom,[148] America[149] and Finland.[51] A subgroup analysis examining the effect of travel time on specific methods of self-harm, found that this effect was most marked for self-harm acts involving minor self-cutting.

Main Findings – The influence of area level determinants on the incidence of suicide

This study is the first to demonstrate marked geographical inequalities in the distribution of suicide in the Republic of Ireland. Overall, (when both genders and all ages were combined) socioeconomic deprivation had the strongest independent effect on small-area rates of suicide, with the most deprived areas showing the greatest risk of suicide (risk ratio=2.1; 95% CI 1.70-2.52). Furthermore, the association between socioeconomic deprivation and suicide held across genders, with this effect being especially marked in the female 15-39 age group. The effect between population density and suicide

was found to differ between males and females. In males, low levels of population density (rurality) were found to be independently associated with increased area level suicide risks. However, in females the association with population density was weaker and less clear. Low levels of population density (rurality) were associated with an increased suicide risk in the female 40-64 age group whereas high levels of population density (urbanicity) were associated with an increased risk in the female 15-39 age group.

Strengths and Limitations of the thesis

This section provides a summary of the overall strengths and limitations of this thesis. The strengths and limitations of the individual studies in this thesis have been acknowledged and discussed in greater detail in the previous chapters.

Strengths and limitations - Risk of suicide and death from other external causes following self-harm (Chapter 4)

This is the first study to be conducted in the Republic of Ireland that examined the risk of suicide and deaths due to other external causes among a national cohort of hospital treated self-harm patients. Internationally, research in this area has been hindered by the fact that few countries have national recording systems for hospital treated self-harm. As a consequence, the majority of research in this area has been based on self-harm populations from single centres or regional multi-centres, however a small number of emerging studies have been carried using national cohorts of hospital treated self-harm patients. The main strength of the study is the large sample size (n=26,168), as a large sample size is necessary to study such a rare outcome as suicide. Furthermore, the large sample size enabled

gender and age-specific effects to be examined in addition to reliable estimates of the clinically important 1-year suicide mortality risk. Moreover, this study was based on all persons that presented to hospital following self-harm, not just those who were subsequently admitted to hospital. This is important, as it has been suggested that there are compositional differences between hospital admission based samples and self-harm hospital attendance samples, as the self-harm cases that lead to inpatient hospital admission are often seen as more serious self-harm cases engaging in more lethal methods of self-harm. Additionally, in this study we examined an individual's last act of self-harm; some studies have examined the index episode of self-harm. It has been suggested that studying an individuals' last act of self-harm is more relevant to the subsequent death than the first (index) episode of self-harm.[27] Lastly, our method of identifying suicides by combining suicide verdicts with those of undetermined intent was used because taking suicide verdicts alone underestimates the overall mortality from suicide.

This study has a number of limitations also. Attrition bias may be an issue as it was not possible to trace the self-harm patients who may have emigrated during the study time period. As the self-harm Registry has national coverage of all hospitals, selection bias is generally not an issue, however, it is plausible that the urban location of the majority of hospitals may lead to an over representation of self-harm cases from urban settings. Furthermore, detailed information on the self-harm patient such as data on suicidal intent, psychosocial assessment, psychiatric diagnosis, marital status and socioeconomic status are not collected by the Registry thus limiting our

ability to control for these potential confounders. Lastly, there are a number of issues associated data linkage techniques. In Ireland there is no unique health identifier; therefore linkage can only be done using a combination of non-unique personal identifiers. There is the possibility of failure to link due to errors in the personal identifier i.e. misspelling of the name or misreporting of date of birth, this may result in failed, incorrect or missed matches. However, the application of probabilistic data linkage algorithms (as used in this study) provides several solutions for the difficulties caused by errors within personal identifiers. Failure to link gives a lower estimate of the actual mortality but does not introduce bias in the study's effect measure. We believe our estimates may be lower than expected rates because the data linkage may not have captured all patients who died in the given period, particularly those who died outside of Ireland.

Strengths and Limitations – Area level determinants of hospital treated deliberate self-harm (Chapter 6) and suicide (Chapter 7)

One of the main strengths of both of the two ecological studies that examined the (1) area level determinants of hospital treated deliberate self-harm and (2) the area level determinants of suicide, is that both studies were carried at a national level. Furthermore, in both studies we stratified by age and gender and examined the findings for effect modification be age and gender. Moreover, for the ecological study of suicide, the study population was based on officially classified suicide death data plus undetermined deaths in order to show that the findings were robust to the effects of misclassification. Lastly, it has been suggested that some of the most widely used socioeconomic deprivation indices may fail to identify rural

socioeconomic deprivation at small geography area level. The socioeconomic deprivation index (HP Pobal Deprivation Index) used in both of the ecological studies in this thesis, is unique compared to other European socioeconomic deprivation indices as it includes a specific measure of rural socioeconomic deprivation (demographic decline), which the authors of this socioeconomic deprivation index state is the most representative measure of rural socioeconomic deprivation.

However, it is important to recognise the inherent limitations associated with ecological studies. Ecological fallacy can occur where the characteristics of an area may not reflect the characteristics of individuals who reside in an area. For example, although we have demonstrated that deprived areas have higher suicide and self-harm rates, the people who die by suicide and self-harm may not share the characteristics of the populations from which they are drawn. However, it is hoped that the use of the smallest spatial area, the DED area, minimized this bias.

Clinical and Public Health Implications

This is the first study in the Republic of Ireland to establish the risk of death due to suicide and other external causes among individuals who presented to hospital due to deliberate self-harm. Research from other countries has shown that deliberate self-harm was one of the strongest risk factors for suicide,[25] however prior to this study, the association between previous self-harm and risk of subsequent suicide had yet to be established in the Republic of Ireland. Therefore, the findings of this thesis contribute to the goals (particularly goal 7) of *Connecting for Life - Ireland's National Strategy to Reduce Suicide 2015-2020.*[179] Goal 7 of the national strategy aims to

improve surveillance, evaluation and high quality research relating to suicidal behaviour. The findings of this thesis showed that even though less than 1% of people presenting to emergency departments following self-harm died by suicide within 1 year, the risk of suicide was 46 times higher in the self-harm population compared to the general population. This highlights the necessity of adequate psychiatric follow up and aftercare for self-harm patients after discharge from hospital. Moreover, our results demonstrate that emergency departments are increasingly important settings for identifying, assessing, and treating adults who self-harm patients are at increased risk of suicide.[180] Each hospital presentation due to self-harm is potentially the patient's last hospital presentation before death, and as such offers an invaluable opportunity to make a lifesaving intervention.[27] Therefore, the findings of this thesis will be of particular interest to hospital staff who manage and treat self-harm patients. It has been suggested that suicide prevention strategies seem to be most effective when implemented consistently during hospital admission, at discharge, and afterwards.[181] Pompili identified factors that could help reduce risk of death post discharge from hospital following self-harm, include: attention to general medical as well as psychiatric needs; enhanced communication among clinicians involved in a patient's current and future care; discharge with a secure aftercare plan with specific appointments and, ideally, contact with the responsible aftercare clinicians before discharge; and involvement of social support by family members or friends.

Furthermore, we have demonstrated that people who engage in major self-cutting were at a greater risk of suicide compared to self-harm patients who

overdosed. Self-cutting is the most common form of non-suicidal self-injury (NSSI).[182] Our findings highlight the elevated risk of suicide in this sub group of self-harm patients and therefore raises concerns about the validity of including NSSI as a separate diagnostic category in in the fifth version of the Statistical and Diagnostic Manual of Mental Disorders (DSM-5). The labelling of suicidal behaviour into two distinct categories, attempted suicide and NSSI may be misleading and create a false dichotomy. Researchers such as Kapur et al. have suggested that for front-line clinical staff the danger of separating behaviours out into two separate diagnostic categories, is that those with NSSI will be *"given lower priority and receive poorer treatment than other patients".*[182] There is evidence to suggest that self-harm patients presenting to hospital due to self-cutting may be regarded as being of limited seriousness by clinical staff and as a result are less likely to be admitted to a hospital ward and receive a psycho-social assessment.[111] The findings from this thesis support the guidelines from the National Institute for Health and Care Excellence Clinical Excellence (NICE) and that all individuals who self-harm irrespective of self-harm method used, risk or need should receive a psychosocial assessment.

Recommendations for policy

Our findings underline and emphasise the importance of treating and diagnosing self-harm patients before they leave the hospital and return home. Suicide is extremely hard to predict, therefore the hospital setting provides a valuable opportunity for intervention. To this end, the results of this thesis supports one the key objectives of the strategy, *Connecting for Life* which aims to ensure that self-harm patients receive care pathways that

are consistent by introducing training and awareness programmes for accident and emergency crisis nurses and other hospital staff to enable them with the skills to identify at risk self-harm patients and to guide them towards support services.

The findings of this thesis have also demonstrated marked geographical inequalities in the geographic distribution of both deliberate self-harm and suicide in Ireland. Therefore, policy makers need to focus on reducing the gaps between the most affluent and most deprived areas, by targeting suicide prevention resources in the most deprived areas. Furthermore, in Ireland inequalities in access to health services are further exacerbating existing health inequalities. Moreover, suicide prevention policy measures need to consider the wider determinants of mental health and well-being. For example, policy measures need to focus on early childhood interventions to tackle the relationship between early childhood disadvantage and poor health outcomes in adult life. Ireland's current national suicide prevention strategy, *Connecting for Life* acknowledges the importance of introducing mental health promotion programmes starting with pre-school and primary school children by adopting whole school approach to teach communication skills, resilience and coping. However, historically in Ireland there has been a lack of specific policy measures aimed at addressing health inequalities. The Samaritans in their recent 2017 report - *Dying From Inequality Socioeconomic Disadvantage and Suicidal Behaviour* [183] has called for *'National suicide prevention strategies to target efforts towards the most vulnerable people and places, in order to reduce geographical inequalities in*

suicide. Every local area should have a suicide prevention plan in place. This should include the development and maintenance.'

Recommendations for future research

This thesis has established the risk of suicide and death from other external causes after self-harm. People who self-harm are not only at risk of dying from suicide, international research has shown that this vulnerable group are also at risk of dying from diseases of the respiratory, circulatory, neurological, endocrine, digestive, skin and musculoskeletal systems.[184] Future research in Ireland should be carried out to build upon the findings of this thesis and examine the risk of all-cause mortality in the self-harm population.

More long-term cohort studies of suicide risk after deliberate self-harm are needed to estimate the true risk over a lifetime perspective. For example, there is a need to better understand the extent to which self-harm in early adolescence may elevate the risk of suicide in adulthood.[185]

Furthermore, more research needs to be carried out to determine whether continuity or switching method of self-harm in a progressively severe is relevant to suicide risk.[186, 187]

However, currently in Ireland research in this area has been greatly hindered by the lack of infrastructure to facilitate record linkage. The absence of a unique health identifier (UHI) for individuals is the single most important deficiency in the Irish health information infrastructure. Ireland has considerable data resources which could be used to enhance our

understanding of suicidal behaviour and improve service delivery and inform suicide prevention policies. A model along with proposals for the types of infrastructure and services required to enable safe access, usage and linkage of data has been proposed by the Health Research Board (HRB) in their report - *Research Evidence Action, the HRB strategy for 2016 – 2020*.[188] It is hoped that this report will provide guidance and facilitate action towards allowing health researchers and policy makers to utilise the wealth of existing datasets to advance the field of suicide research.

Conclusion

Our study reinforces findings from previous research showing an elevated risk of both suicide and non-suicide external cause mortality in self-harm patients compared to the general population and that the risk of mortality differs by age and gender. The findings from this thesis also demonstrate marked geographical inequalities in the distribution of both suicide and self-harm in Ireland and highlight the importance of targeting suicide prevention resources in the most deprived areas.

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Appendix 1. Ethical Approval from Clinical Research Ethics Committee (CREC)

UCC
COISTE EITICE UM THAIGHDE CLINICIÚIL
Clinical Research Ethics Committee
Tel: + 353-21-490 1901
Fax: + 353-21-490 1919
Lancaster Hall,
6 Little Hanover Street,
Cork,
Ireland.
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

Our ref: ECM 4 (z) 08/11/11

20th October 2011

Professor Ivan Perry
Dept of Epidemiology & Public Health
Second Floor
Brookfield Health Sciences Complex
University College Cork
College Road
Cork

Re: Understanding deliberate self harm in Ireland: incidence, repetition and related risk of death – a national perspective.

Dear Professor Perry

Expedited approval is granted to carry out the above study at:

- The National Suicide Research Foundation
- Central Statistics Office.

The following documents were approved:

- Application Form
- Detailed Protocol Version 1 dated 17th October 2011.

We note that the co-investigators involved in this study will be:

- Dr Paul Corcoran and Irene O'Farrell.

Yours sincerely

Dr Michael Hyland
Chairman
Clinical Research Ethics Committee
of the Cork Teaching Hospitals

The Clinical Research Ethics Committee of the Cork Teaching Hospitals, UCC, is a recognised Ethics Committee under Regulation 7 of the European Communities (Clinical Trials on Medicinal Products for Human Use) Regulations 2004, and is authorised by the Department of Health and Children to carry out the ethical review of clinical trials of investigational medicinal products. The Committee is fully compliant with the Regulations as they relate to Ethics Committees and the conditions and principles of Good Clinical Practice.

Appendix 2. Letter of Approval from the General Register Office (GRO)

n tSeirbhís um Chlárú Sibhialta
fig an Ard-Chláraitheora
gí an Rialtais, Bóthar an Chlochair, Ros Comáin, Co. Ros Comáin.

Civil Registration Service
Office of the Registrar General
Government Offices, Convent Road, Roscommon, Co. Roscomm

Tel: (090) 663 2900 Extn:
LoCall: 1890 252076
Fax: (090) 663 2999
Website: www.groireland.ie

Our Ref:

Your Ref:

Paul Corcoran,
Deputy Director/Senior Statistician,
National Suicide Research Foundation,
1 Perrott Avneue,
College Road,
Cork.

10th February 2012.

Dear Mr.Corcoran,

I refer to your recent letter requesting release by the Central Statistics Office (CSO) of electronic data in relation to deaths that occurred or were registered in 2006 and subsequent years.

You have clarified that you have already been in touch with the CSO in this regard.

I am directed by the Minister for Social Protection to authorise the release of data you have requested subject to –

1. the following conditions: (The conditions you agreed to in your letter have been noted)

- the authorisation to access this data is granted solely for the purpose as outlined in your request;
- under no circumstances should this data be used as a basis for contacting relatives of individuals named in or identifiable from the data;
- any materials that may be published based on this data must be at a level of aggregation sufficient to preclude the possibility of identification of individuals, and
- copies of the data must not be made available to third parties or be used in further research projects without specific authorisation.

2. any terms and conditions stipulated by the CSO in relation to the matter.

tSeirbhís um Chlárú Sibhialta
g an Ard-Chláraitheora
an Rialtais, Bóthar an Chlochair, Ros Comáin, Co. Ros Comáin.

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Website: www.groireland.ie

Our Ref:

Your Ref:

While data protection legislation applies to living individuals only, the Medical Council's Guide to Ethical Conduct and Behaviour refers to confidentiality of patient information extending beyond death.

I trust you find these conditions acceptable. Your use of the data will indicate your acceptance of these terms. A copy of this letter has been forwarded to Ms. Sandra Tobin in the CSO for her information.

Yours sincerely,

Catherine Keane

Catherine Keane
General Register Office

Appendix 3. Table 7.4 - Associations between suicide and deprivation, social fragmentation and population density in persons aged 15-64 years across two time periods, 2006-2007 and 2009-2011

	Adjusted IRR[1] (2006-2007)				Adjusted IRR[2] (2009-2011)			
	Quintile 2	**Quintile 3**	**Quintile 5**	**Quintile 5**	**Quintile 2**	**Quintile 3**	**Quintile 5**	**Quintile 5**
Deprivation	1.3 0.98-1.62	1.4 1.08-1.79	1.8 1.43-2.38	2.3 1.77-2.91	1.3 1.11-1.52	1.5 1.26-1.8	1.6 1.35-2	2.1 1.70-2.52
Social Fragmentation	1.1 0.84-1.47	1 0.71-1.37	1.2 0.91-1.62	1.2 0.91-1.59	1.0 0.81-1.37	1.1 0.9-1.42	1.1 0.87-1.3	1.2 0.98-1.54
Population Density	0.7 0.5-1.12	0.9 0.67-1.33	0.9 0.6-1.23	0.8 0.58-1.2	0.9 0.63-1.17	0.8 0.66-1.05	0.8 0.63-0.95	0.7 0.55-0.98

[1] Incidence rate ratios of suicide in persons aged 15to64 years for the time period 2006 to 2007 after controlling for all the other explanatory variables including age and gender. Measures of deprivation, social fragmentation and population density were based on the 2006 Census.

[2] Incidence rate ratios of suicide in persons aged 15to64 years for the time period 2009 to 2011 after controlling for all the other explanatory variables including age and gender. Measures of deprivation, social fragmentation and population density were based on the 2011 Census.